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THE STUDY OF SOCIOLOGY.

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VI.—*Subjective Difficulties—Intellectual.*

IF you watch the management of a child by a mother of small capacity, you may be struck by the inability she betrays to imagine the child's thoughts and feelings. Full of energy which he must expend in some way, and eager to see every thing, her little boy is every moment provoking her by his restlessness. The occasion is perhaps a railway journey. Now he strives to look out of the window; and now, when forbidden to do that, climbs on the seats, or meddles with the small luggage. "Sit still," "Get down, I tell you," "Why can't you be quiet?" are the commands and expostulations she utters from minute to minute—partly, no doubt, to prevent the discomfort of fellow-passengers. But, as you will see at other times, when no such motive comes into play, she endeavors to repress these childish activities mainly out of regard for what she thinks propriety, and does it without any adequate recognition of the penalties she inflicts. Though she herself lived through this phase of extreme curiosity—this early time when almost every object passed has the charm of novelty, and when the overflowing energies generate a painful irritation if pent up; yet now she cannot believe how keen is the desire for seeing which she balks, and how difficult is the maintenance of that quietude on which she insists. Conceiving her child's consciousness in terms of her own consciousness, and feeling how easy it is to sit still and not look out of the window, she ascribes his behavior to mere perversity.

I recall this and kindred experiences to the reader's mind, for the purpose of exemplifying a necessity and a difficulty. The necessity is that, in dealing with other beings and interpreting their actions, we are obliged to represent their thoughts and feelings in terms of our

own. The difficulty is that, in so representing them, we can never be more than partially right, and are frequently very wrong. The conception which any one frames of another's mind, is inevitably more or less after the pattern of his own mind—is automorphic; and in proportion as the mind of which he has to frame a conception differs from his own, his automorphic interpretation is likely to be wide of the truth.

That measuring other person's actions by the standards our own thoughts and feelings furnish, often causes misconstruction, is indeed a truth familiar even to the vulgar. But while among members of the same society, having natures nearly akin, it is seen that automorphic explanations are often erroneous, it is not seen with due clearness how much more erroneous such explanations commonly are, when the actions are those of men of another race, to whom the kinship in nature is comparatively remote. We do, indeed, perceive this, if the interpretations are not our own; and if both the interpreters and the interpreted are distant in thought and nature from ourselves. When, as in early English literature, we find Greek history conceived in terms of feudal institutions, and the heroes of antiquity spoken of as princes, knights, and squires, it becomes clear to us that the ideas concerning ancient civilization must have been utterly wrong. When we find Virgil adopted by Dante as his guide, and named elsewhere as one among the prophets who visited the cradle of Christ—when an illustrated psalter gives scenes from the life of Christ in which there repeatedly figures a castle with a portcullis—when even the Crucifixion is described by Langland in the language of chivalry, so that the man who pierced Christ's side with a spear is considered as a knight who disgraced his knighthood[1]—when we read of the Crusaders calling themselves "vassals of Christ;" we need no further proof that by carrying their own sentiments, and ideas, and habits, to the interpretation of social arrangements and transactions among the Jews, our ancestors were led into absurd misconceptions. But we do not recognize the fact that in virtue of the same tendency we are ever framing conceptions which, if not so grotesquely untrue, are yet very wide of the truth. How difficult it is to imagine mental states remote from our own so correctly that we can understand how they issue in individual actions, and consequently in social actions, an instance will make manifest.

The feeling of vague wonder with which he received his first lessons in the Greek mythology, will most likely be dimly remembered by every reader. If not in words, still in an inarticulate way, there passed through him the thought that belief in such stories was unaccountable. When, afterward, he read in books of travels details of the amazing superstitions of this or that race of savages, there was joined with a sense of the absurdity of such superstitions, more or less of astonishment at their acceptance by any human beings, however

[1] Warton's "History of English Poetry," vol. ii., p. 57, note.

ignorant or stupid. That the people of a neighboring tribe had descended from ducks, that rain resulted when certain deities began to spit upon the earth, that the island lived upon had been pulled up from the bottom of the ocean by one of their gods, whose hook got fast when he was fishing—these and countless beliefs equally laughable seem to him to imply an irrationality near to insanity. He interprets them automorphically—carrying with him not simply his own faculties developed to a stage of complexity considerably beyond that reached by the faculties of the savage, but also the modes of thinking in which he was brought up, and the stock of information he has acquired. Usually it never occurs to him to do otherwise. Even if he attempts to look at things from the savage's point of view, he most likely fails entirely; and, if he succeeds at all, it is but very partially. Yet only by seeing things as the savage sees them can his ideas be understood, his behavior accounted for, and the resulting social phenomena explained. These seemingly-strange superstitions are quite natural—quite rational, in a certain sense, in their respective times and places. The laws of intellectual action are the same for civilized and uncivilized. The difference is in complexity of faculty and amount of knowledge accumulated and generalized. Given reflective powers developed only to that lower degree in which they are possessed by the aboriginal man—given his small stock of ideas, collected in a narrow area of space, and not added to by records extending through time—given his impulsive nature incapable of patient inquiry; and these seemingly-monstrous beliefs of his become in reality the most feasible explanations he can find of surrounding things. Yet even after seeing that this must be so, it is not easy to think, from the savage's point of view, clearly enough to follow the effects of his ideas on his acts, through all the relations of life, social and other.

A parallel difficulty stands in the way of rightly conceiving character remote from our own, so as to see how it issues in conduct. We may best recognize our inability in this respect by observing the converse inability of other races to understand our characters, and the acts they prompt.

"Wonderful are the works of Allah! Behold! That Frank is trudging about, when he can, if he pleases, sit still!" [1]

In like manner Captain Speke tells us:

"If I walked up and down the same place to stretch my legs, they" (Somali) "formed councils of war on my motives, considering I must have some secret designs upon their country, or I would not do it, as no man in his senses could be guilty of working his legs unnecessarily." [2]

But while by instances like these we are shown that our characters are in a large measure incomprehensible by races remote in nature

[1] Burton's "Scinde," vol. ii., p. 13.

[2] Speke's "Journal of Discovery of Source of the Nile," p. 85.

from ourselves, the correlative fact that their sentiments and motives cannot be rightly conceived by us, is one perpetually overlooked in our sociological interpretations. Feeling, for instance, how natural it is to take an easier course in place of a more laborious course, and to adopt new methods that are proved to be better methods, we are somewhat puzzled on finding the Chinese stick to their dim paper-lamps, though they admire our bright argand-lamps, which they do not use if given to them; or on finding that the Hindoos prefer their rough primitive tools after seeing that our greatly-improved tools do more work with less effort. And, on descending to races yet more remote in civilization, we still oftener discover ourselves wrong when we suppose that under given conditions they will act as we should act.

Here, then, is a subjective difficulty of a serious kind. Properly to understand any fact in social evolution, we have to see it as resulting from the joint actions of individuals having certain natures. We cannot so understand it without understanding their natures; and this, even by care and effort, we are able to do but very imperfectly. Our interpretations must be in a greater or less degree automorphic; and yet automorphism perpetually misleads us.

One would hardly suppose, *a priori*, that untruthfulness would habitually coexist with credulity. Rather our inference might be, that, in virtue of the tendency above enlarged upon, people most given to make false statements must be people most inclined to suspect statements made by others. Yet somewhat anomalously, as it seems, habitual veracity very generally goes with inclination to doubt evidence; and extreme untrustworthiness of assertion often has, for its concomitant, readiness to accept the greatest improbabilities on the slenderest testimony. If you compare savage with civilized, or compare the successive stages of civilization, you find untruthfulness and credulity decreasing together; until you reach the modern man of science, who is at once exact in his statements and critical respecting the evidence on which facts are alleged. The converse relation to that which we see in the man of science is even now very startlingly presented in the East, where greediness in swallowing fictions goes along with superfluous telling of falsehoods. An Egyptian prides himself in a clever lie, uttered even without motive; and a dyer will even ascribe the failure in fixing one of his colors to the not having been successful in a deception. Yet so great is the readiness to believe improbabilities that Mr. St. John, in his "Two Years' Residence in a Levantine Family," narrates how, when the "Arabian Nights' Entertainments" was being read aloud, and when he hinted that the stories must not be accepted as true, there arose a strong protest against such skepticism—the question being asked, "Why should a man sit down and write so many lies?"[1]

[1] *See* pp. 79 and 127.

I point out this union of seemingly-inconsistent traits, not because of the direct bearing it has on the argument, but for the sake of its indirect bearing. For I have here to dwell awhile on the misleading effects of certain mental tendencies which similarly appear very unlikely to coexist, and which yet do habitually coexist. I refer to the belief which, even while I write, I find repeated in the leading journal, that "the deeper a student of history goes, the more does he find man the same in all time;" and to the quite opposite belief embodied in current politics, that human nature may be readily altered. These two beliefs, which ought to cancel one another but do not, originate two classes of errors in sociological speculation; and nothing like correct conclusions in Sociology can be drawn until they have been rejected, and replaced by a belief which reconciles them—the belief that human nature is indefinitely modifiable, but that no modification of it can be brought about rapidly. We will glance at the errors to which each of these beliefs leads.

While it was held that the stars are fixed and that the hills are everlasting, there was a certain congruity in the notion that man continues unchanged from age to age; but now when we know that all stars are in motion, and that there are no such things as everlasting hills—now that we find all things throughout the Universe to be in a ceaseless flux, it is time for this crude conception of human nature to disappear out of our social conceptions; or rather—it is time that its disappearance should be followed by that of the many narrow notions respecting the past and the future of society, which have grown out of it, and which linger notwithstanding the loss of their root. For, avowedly by some and tacitly by others, it continues to be thought that the human heart is as "desperately wicked" as it ever was, and that the state of society hereafter will be very much like the state of society now. If, when the evidence has been piled mass upon mass, there comes a reluctant admission that aboriginal man, of troglodyte or kindred habits, differed somewhat from man as he was during feudal times, and that the customs and sentiments and beliefs he had in feudal times imply a character appreciably unlike that which he has now—if, joined with this, there is a recognition of the truth that along with these changes in man there have gone still more conspicuous changes in society; there is, nevertheless, an ignoring of the implication that hereafter man and society will continue to change, until they have diverged as widely from their existing types as their existing types have diverged from those of the earliest recorded ages. It is true that among the more cultured, the probability, or even the certainty, that such transformations will go on, may be granted; but the granting is but nominal, the admission does not become a factor in the conclusions drawn. The first discussion on a political or social topic reveals the tacit assumption that in times to come society will have a structure substantially like its existing structure. If, for instance, the question

of domestic service is raised, it mostly happens that its bearings are considered wholly in reference to those social arrangements which exist around us; only a few proceed on the supposition that these arrangements are probably but transitory. It is so throughout. Be the subjects industrial organization, or class-relations, or rule by fashion, the belief which practically moulds the conclusions, if not the belief theoretically professed, is, that, whatever changes they may undergo, our institutions will not cease to be recognizably the same. Even those who have, as they think, deliberately freed themselves from this perverting tendency—even M. Comte and his disciples, believing in an entire transformation of society, nevertheless betray an incomplete emancipation; for the ideal society believed in by them, is one under regulation by a hierarchy essentially akin to hierarchies such as mankind have known. So that everywhere, more or less, sociological thinking is impeded by the difficulty of constantly bearing in mind that the social states toward which mankind are being carried are probably as little conceivable by us as our present state was conceivable by a Norse pirate and his followers.

Note, now, the contrary difficulty, which appears to be surmountable by scarcely any of our parties, political and philanthropic, from the highest to the lowest—the difficulty of understanding that human nature, though indefinitely modifiable, can be modified but very slowly; and that all laws and institutions and appliances, which count on getting from it within a short time much better results than present ones, will inevitably fail. If we glance over the programmes of societies, and sects, and schools of all kinds, from Rousseau's disciples in the French Convention down to the members of the United Kingdom Alliance, from the adherents of the Ultramontane propaganda down to the enthusiastic advocates of an education exclusively secular, we find in them one common trait. They are all pervaded by the conviction, now definitely expressed and now taken as a self-evident truth, that there needs but this kind of instruction or that kind of discipline, this mode of repression or that system of culture, to bring society into a very much better state. Here we read that "it is necessary completely to refashion the people whom one wishes to make free:" the implication being that a refashioning is practicable. There it is taken as self-evident that, when you have taught children what they ought to do to be good citizens, they will become good citizens. Elsewhere it is held to be a truth beyond question that, if by law temptations to drink are removed from men, they will not only cease to drink, but thereafter cease to commit crimes. And yet the delusiveness of all such hopes is obvious enough to any one not blinded by an hypothesis, or carried away by an enthusiasm. The fact, often pointed out to Temperance-fanatics, that some of the soberest nations in Europe yield a proportion of crime higher than our own, might suffice to show them that England would not be suddenly

moralized if they carried their proposed restrictions into effect. The superstition that good behavior is to be forthwith produced by lessons learned out of school-books, which was long ago statistically disproved,[1] would, but for preconceptions, be utterly dissipated by observing to what a slight extent knowledge affects conduct—by observing that the dishonesty implied in the adulterations of tradesmen and manufacturers, in fraudulent bankruptcies, in bubble-companies, in "cooking" of railway accounts and financial prospectuses, differs only in form, and not in amount, from the dishonesty of the uneducated—on observing how amazingly little the teachings given to medical students affect their lives, and how even the most experienced medical men have their prudence scarcely at all increased by their information. Similarly, the Utopian ideas which come out afresh along with every new political scheme, from the "paper-constitutions" of the Abbé Sieyès down to the just-published programme of M. Louis Blanc, and from agitations for vote-by-ballot up to those who have a republic for their aim, might, but for this tacit belief we are contemplating, be extinguished by the facts perpetually and startlingly thrust on our attention. Again and again for three generations has France been showing to the world how impossible it is essentially to change the type of a social structure by any rearrangement wrought out through a revolution. However great the transformation may for a time seem, the original thing reappears in disguise. Out of the nominally-free government set up, a new despotism arises, different from the old by having a new shibboleth and new men to utter it; but identical with the old in the determination to put down opposition, and in the means used to this end. Liberty, when obtained, is forthwith surrendered to an avowed autocrat; or, as we have seen within this year, it is allowed to lapse into the hands of one who claims the reality of autocracy without its title. Nay, the change is, in fact, even less; for the regulative organization which ramifies throughout French society continues unaltered by these changes at the governmental centre. The bureaucratic system persists equally under Imperialist, Constitutional, and Republican arrangements. As the Duc d'Audriffret-Pasquier pointed out, "Empires fall, Ministers pass away, but Bureaux remain." The aggregate of forces and tendencies embodied, not only in the structural arrangements holding the nation together, but in the ideas and sentiments of its units, is so powerful that the excision of a part, even though it be the governmental centre, is quickly followed by the substitution of a like part. It needs but to recall the truth exemplified some chapters back, that the properties of the aggregate are determined by the properties of the units, to see at once that, so long as the characters of citizens remain substantially unchanged, there can be no substantial change in the political organization which has slowly been evolved by them.

[1] "Summary of the Moral Statistics of England and Wales." By Joseph Fletcher, Esq., one of her Majesty's Inspectors of Schools.

This double difficulty of thought, with the double set of delusions fallen into by those who do not surmount it, is, indeed, naturally associated with the once-universal, and still-general, belief that societies arise by manufacture, instead of arising, as they do, by evolution. Recognize the truth that aggregates of men, like other aggregates, grow, and acquire their structural characters through a process of modification upon modification, and there are excluded these antithetical errors that man remains the same and that man is readily alterable; and along with exclusion of these errors comes admission of the inference that the changes which have brought social arrangements to a form so different from past forms will in future carry them on to forms as different from those now existing. Once become habituated to the thought of a continuous unfolding of the whole and of each part, and these misleading ideas disappear. Take a word and observe how, while changing, it gives origin in course of time to a family of words, each changing member of which similarly has progeny; take a custom, as that of giving eggs at Easter, which has now developed in Paris into the fashion of making expensive presents of every imaginable kind enclosed in imitation-eggs, becoming at length large enough to contain a brougham, and which entails so great a tax that people go abroad to evade it; take a law, once quite simple and made to meet a special case, and see how it eventually, by successive additions and changes, grows up into a complex group of laws, as, out of two statutes of William the Conqueror came our whole system of statutes regulating land-tenure;[1] take a social appliance, like the press, and see how from the news-letter, originally private and written, and then assuming the shape of a printed fly-leaf to a written private letter, there has, little by little, evolved this vast assemblage of journals and periodicals, daily, weekly, general, and local, that have, individually and as an aggregate, grown in size while growing in heterogeneity —do this, and do the like with all other established institutions, agencies, products, and there will come naturally the conviction that now, too, there are various germs of things which will in the future develop in ways no one imagines and take shares in profound transformations of society and of its members—transformations that are hopeless as immediate results, but certain as ultimate results.

Try to fit a hand with five fingers into a glove with four. Your difficulty aptly parallels the difficulty of putting a complex conception into a mind not having an adequately complex faculty. In proportion as the several terms and relations which make up a thought become numerous and varied, there must be brought into play numerous and varied parts of the intellectual structure, before the thought can be comprehended; and, if some of these parts are wanting, only fragments of the thought, and not the thought as a whole, can be taken in. Con-

[1] Reeves, "History of English Law," vol. i., pp. 34–36 (second edition).

sider an instance. What is meant by the ratio of A to B may be explained to a boy, by drawing a short line A and a long line B, telling him that A is said to bear a small ratio to B; and then, after lengthening the line A, telling him that A is now said to bear a larger ratio to B. But suppose I have to explain what is meant by saying that the ratio of A to B is equal to the ratio of C to D. This conception is much more complex: instead of two different quantities and one relation, there are four different quantities and three relations. To understand the proposition, the boy has to think of A and B and their difference, and, without losing his intellectual grasp of these, he has to think of C and D and their difference, and, without losing his intellectual grasp of these, he has to think of the two differences as each having a like relation to its pair of quantities. Thus the number of terms and relations to be kept before the mind is such as to imply the cooperation of many more agents of thought, any of which being absent, the proposition cannot be understood: the boy must be older before he will understand it, and, if uncultured, will probably never understand it at all. Pass now to a conception of still greater complexity—say that the ratio of A to B varies as the ratio of C to D. Far more numerous things have now to be represented in consciousness with approximate simultaneity. A and B have to be thought of as not constant in their lengths, but as one or both of them changing in their lengths, so that their difference is indefinitely variable. Similarly with C and D. And then the variability of the ratio in each case being duly conceived in terms of lines that lengthen and shorten, the thing to be understood is, that whatever difference any change brings about between A and B, the relation it bears to one or other of them is always like that which the difference simultaneously arising between C and D bears to one or other of them. The greater multiplicity of ideas required for mentally framing this proposition evidently puts it further beyond the reach of faculties not developed by appropriate culture, or not capable of being so developed. And as the type of proposition becomes still more involved, as it does when two such groups of dependent variables are compared and conclusions drawn, it begins to require a grasp that is easy only to the disciplined mathematician.

One who does not possess that complexity of faculty which, as we here see, is requisite for the grasping of a complex conception, may, in cases like these, become conscious of his incapacity; not from perceiving what it is that he lacks, but from perceiving that, by another person, results can be achieved which he cannot achieve. But, where no such thing as the verifying of exact predictions comes in to prove to one of inferior faculty that his faculty is inferior, he is usually unaware of the inferiority. To imagine a higher mode of consciousness is in some degree to have it; so that, until he has it in some degree, he cannot really conceive of its existence. An illustration or two will make this clear.

Take a child on your knee, and, turning over with him some engravings of landscapes, note what he observes. "I see a man in a boat," says he, pointing. "Look at the cows coming down the hill." "And see, there is a little boy playing with a dog." These and other such remarks, mostly about the living objects in each view, are all you get from him. Never by any chance does he utter a word respecting the scene as a whole. There is an absolute unconsciousness of any thing to be observed, or to be pleased with, in the combination of wood and water and mountain. And, while the child is entirely without this complex æsthetic consciousness, you see that he has not the remotest idea that such a consciousness exists in others, but is wanting in himself. Take, now, a case in which a kindred defect is betrayed by an adult. You have, perhaps, in the course of your life, had some musical culture, and can recall the stages through which you have passed. In early days a symphony was a mystery, and you were somewhat puzzled to find others applauding it. An unfolding of musical faculty, that went on slowly through succeeding years, brought some appreciation, and now these complex musical combinations, which once gave you little or no pleasure, give you more pleasure than any others. Remembering all this, you begin to suspect that your indifference to certain still more involved musical combinations may arise from incapacity in you, and not from defects in them. See, on the other hand, what happens with one who has undergone no such series of changes —say, an old naval officer, whose life at sea kept him out of the way of concerts and operas. You hear him occasionally confess, or rather boast, how much he enjoys the bagpipes. While the last cadences of a sonata, which a young lady has just played, are still in your ears, he goes up to her and asks whether she can play "Polly, put the kettle on," or "Johnny comes marching home." And then, when concerts are talked about at table, he seizes the occasion for expressing his dislike of classical music, and scarcely conceals his contempt for those who go to hear it. On contemplating his mental state, you see that, along with absence of the faculty for grasping complex musical combinations, there goes no consciousness of the absence—there is no suspicion that such complex combinations exist, and that other persons have faculties for appreciating them.

And now for the application of this general truth to our subject. The conceptions with which sociological science is concerned are complex beyond all others. In the absence of faculty having a corresponding complexity, they cannot be grasped. Here, however, as in other cases, the absence of an adequately complex faculty is not accompanied by any consciousness of incapacity. Rather do we find that, in proportion to the deficiency in the required kind of mental grasp, there is an extreme confidence of judgment on sociological questions, and a ridicule of those who, after long discipline, begin to perceive what there is to be understood, and how difficult is the right un-

derstanding of it. A simple illustration of this will prepare the way for more involved illustrations.

A few months ago, the *Times* gave us an account of the last achievement in automatic printing—the "Walter Press," by which its own immense edition is thrown off in a few hours every morning. Suppose a reader of the description, adequately familiar with mechanical details, follows what he reads step by step with full comprehension—perhaps making his ideas more definite by going to see the apparatus at work and questioning the attendants? Now he goes away considering he understands all about it. Possibly, under its aspect as a feat in mechanical engineering, he does so. Possibly also, under its biographical aspect, as implying in Mr. Walter and those who coöperated with him certain traits, moral and intellectual, he does so. But under its sociological aspect he has no notion of its meaning, and does not even suspect that it has a sociological aspect. Yet, if he begins to look into the genesis of the thing, he will find that he is but on the threshold of the full explanation. On asking not what is its proximate but what is its remote origin, he finds, in the first place, that this automatic printing-machine is lineally descended from other automatic printing-machines, which have undergone successive developments—each presupposing others that went before: without cylinder printing-machines long previously used and improved, there would have been no "Walter Press." He inquires a step further, and discovers that this last improvement became possible only by the help of *papier-mâché* stereotyping, which, first employed for making flat plates, afforded the possibility of making cylindrical plates. And tracing this back, he finds that plaster-of-paris stereotyping came before it, and that there was another process before that. Again he learns that this highest form of automatic printing, like the many less-developed forms preceding it, depended for its practicability on the introduction of rollers for distributing ink, instead of the hand-implements used by "printer's-devils" fifty years ago—which rollers, again, could never have been made fit for their present purposes, without the discovery of that curious elastic compound out of which they are cast. And then, on tracing the more remote antecedents, he finds an ancestry of hand printing-presses, which, through generations, had been successively improved. Now, perhaps, he thinks he understands the apparatus, considered as a sociological fact. Far from it. Its multitudinous parts, which will work together only when highly finished and exactly adjusted, came from machine-shops, where there are varieties of complicated, highly-finished engines for turning cylinders, cutting out wheels, planing bars, and so forth; and on the preëxistence of these the existence of this printing-machine depended. If he inquires into the history of these complex automatic tools, he finds they have severally been, in the slow course of mechanical progress, brought to their present perfection by the help of

preceding complex automatic tools of various kind, that coöperated to make their component parts—each larger, or more accurate, lathe or planing-machine having been made possible by preëxisting lathes and planing-machines, inferior in size or exactness. And so if he traces back the whole contents of the machine-shop, with its many different instruments, he comes in course of time to the blacksmith's hammer and anvil, and even, eventually, to still ruder appliances. The explanation is now completed, he thinks. Not at all. No such process as that which the "Walter Press" shows us was possible until there had been invented, and slowly perfected, a paper-machine capable of making miles of paper without break. Thus there is the genesis of the paper-machine involved, and that of the multitudinous appliances and devices that preceded it, and are at present implied by it. Have we now got to the end of the matter? No; we have just glanced at one group of the antecedents. All this development of mechanical appliances—this growth of the iron-manufacture, this extensive use of machinery made from iron, this production of so many machines for making machines—has had for one of its causes the abundance of the raw materials, coal and iron; has had for another of its causes the insular position which has favored peace and the increase of industrial activity. There have been moral causes at work too. Without that readiness to sacrifice present ease to future benefit, which is implied by enterprise, there would not only have never arisen the machine in question, but there would never have arisen the multitudinous improved instruments and processes that have made it possible. And, beyond the moral traits which enterprise presupposes, there are those presupposed by efficient coöperation. Without mechanical engineers who fulfilled their contracts tolerably well, by executing work accurately, neither this machine itself nor the machines that made it could have been produced; and, without artisans having considerable conscientiousness, no master could insure accurate work. Try to get such products out of an inferior race, and you will find defective character an insuperable obstacle. So, too, will you find defective intelligence an insuperable obstacle. The skilled artisan is not an accidental product, either morally or intellectually. The intelligence needed for making a new thing is not everywhere to be found; nor is there everywhere to be found the accuracy of perception and nicety of execution without which no complex machine can be so made that it will act. Exactness of finish in machines has developed *pari passu* with exactness of perception in artisans. Inspect some mechanical appliance made a century ago, and you may see that, even had all other requisite conditions been fulfilled, want of the requisite skill in workmen would have been a fatal obstacle to the production of an engine requiring so many delicate adjustments. So that there are implied in this mechanical achievement, not only our slowly-generated industrial state, with

its innumerable products and processes, but also the slowly-moulded moral and intellectual natures of masters and workmen. Has nothing now been forgotten? Yes, we have left out a whole division of all-important social phenomena—those which we group as the progress of knowledge. Along with the many other developments that have been necessary antecedents to this machine, there has been the development of Science. The growing and improving arts of all kinds have been helped up, step after step, by those generalized experiences, becoming ever wider, more complete, more exact, which make up what we call Mathematics, Physics, Chemistry, etc. Without a considerably developed Geometry, there could never have been the machines for making machines; still less this machine that has proceeded from them. Without a developed Physics, there would have been no steam-engine to move these various automatic appliances, primary and secondary; nor would the many implied metallurgic processes have been brought to the needful perfection. And, in the absence of a developed Chemistry, many of the requirements, direct and indirect, could not have been adequately fulfilled. So that, in fact, this organization of knowledge which began with civilization had to reach something like its present stage, before such a machine could come into existence, supposing all other prerequisites to be satisfied. Surely we have now got to the end of the history. Not quite; there yet remains an essential factor. No one goes on year after year spending thousands of pounds, and much time, and persevering through disappointment and anxiety, without a strong motive: the "Walter Press" was not a mere *tour de force*. Why, then, was it produced? To meet an immense demand with great promptness—to print, with one machine, 16,000 copies per hour. Whence arises this demand? From an extensive reading public, brought in the course of generations to have a keen morning-appetite for news of all kinds—merchants who need to know the latest prices at home and the latest telegrams from abroad; politicians who must learn the result of last night's division, be informed of the latest diplomatic move, and read the speeches at a meeting; sporting-men who look for the odds and the result of yesterday's race; ladies who want to see the births, marriages, and deaths. And, on asking the origin of these many desires to be satisfied, they prove to be concomitants of our social state in general—its trading, political, philanthropic, and other activities; for, in societies where these are not dominant, the demand for news of various kinds rises to no such intensity. See, then, how enormously involved is the genesis of this machine, as a sociological phenomenon. A whole encyclopædia of mechanical inventions—some dating from the earliest times—go to the explanation of it. Thousands of years of discipline, by which the impulsive, improvident nature of the savage has been evolved into a comparatively self-controlling nature, capable of sacrificing present ease to future good, are presupposed. There is presupposed the

equally long discipline by which the inventive faculty, almost wholly absent in the savage, has been evolved, and by which accuracy, not even conceived by the savage, has been cultivated. And there is further presupposed the slow political and social progress, at once cause and consequence of these other changes, that has brought us to a state in which such a machine finds a function to fulfil.

The complexity of a sociological fact, and the difficulty of adequately grasping it, will now perhaps be more apparent. For as in this case there has been a genesis, so has there been in every other case, be it of institution, arrangement, custom, belief, etc.; but while in this case the genesis is comparatively easy to trace, because of the comparatively concrete character of process and product, it is in other cases difficult to trace, because the factors are mostly not of a sensible kind. And yet only when the genesis has been traced—only when the various antecedents of all orders have been observed in their coöperation, generation after generation, through past social states—is there reached that interpretation of a fact which makes it a part of sociological science, properly understood. If, for instance, the true meaning of such phenomena as those presented by trade-combinations is to be seen, it is needful to go back to those remote old English periods when analogous causes produced analogous results. As Brentano points out:

"The workmen formed their Trade-Unions against the aggressions of the then rising manufacturing lords, as in earlier times the old freemen formed their Frith-Gilds against the tyranny of mediæval magnates, and the free handicraftsmen their Craft-Gilds against the aggressions of the Old-burghers." [1]

Then, having studied the successive forms of such organizations in relation to the successive industrial states, there have to be observed the ways in which they are severally related to other phenomena of their respective times—the political institutions, the class distinctions, the family arrangements, the modes of distribution and degrees of intercourse between localities, the amounts of knowledge, the religious beliefs, the morals, the sentiments, the customs, the ideas. Considered as parts of a nation, having structures that form parts of its structure and actions that modify and are modified by its actions, these trade-societies can have their full meanings perceived only when they are studied in their serial genesis through many centuries, and their changes considered in relation to simultaneous changes throughout the social organism. And even then there remains the deeper inquiry—How does it happen that in nations of certain types no analogous institutions exist, and that in nations of other types the analogous institutions have taken forms more or less different?

That phenomena so involved cannot be seen as they truly are, even by the highest intelligence at present existing, is tolerably manifest. And it is manifest also that a Science of Society is likely for a long

[1] Brentano's "Introduction to Early English Guilds," p. cxiv.

time hence to be recognized by but few; since not only is there in most cases an absence of faculty complex enough to grasp its complex phenomena, but there is mostly an absolute unconsciousness that there are any such complex phenomena to be grasped.

To the want of a due complexity of conceptive faculty, there has to be added, as a further difficulty, the want of due plasticity of conceptive faculty. The general ideas of nearly all men have been framed out of experiences gathered within comparatively narrow areas; and general ideas so framed are far too rigid readily to admit the multitudinous and varied combinations of facts which Sociology presents. The child of Puritanic parents, brought up in the belief that Sabbath-breaking brings after it all kinds of transgressions, and having had pointed out, in the village or small town that formed his world, various instances of this connection, is somewhat perplexed in after-years, when acquaintance with more of his countrymen has shown him exemplary lives joined with non-observance of the Sunday. When he adds to his experiences by Continental travel, and finds that the best people of foreign societies disregard injunctions which he once thought essential to right conduct, he still further widens his originally small and stiff conception. Now, the process thus exemplified, in a single belief of a comparatively superficial kind, has to be gone through with numerous beliefs of deeper kinds, before there can be reached the flexibility of thought required for dealing properly with sociological phenomena. Not in one direction, but in nearly all directions, we have to learn that those connections of social facts which we commonly regard as natural, and even necessary, are not at all necessary, and often have no particular naturalness. On contemplating past social states, we are continually reminded that many arrangements, and practices, and convictions, that seem matters of course, are very modern; and we are continually forgetting that many things we now regard as impossible were quite possible a few centuries ago. Still more, on studying societies alien in race as well as in stage of civilization, we perpetually meet with things not only contrary to every thing we should have thought probable, but even such as we should have scarcely hit upon in trying to conceive the most unlikely and even impossible things.

Take in illustration the varieties of domestic relations. That monogamy is not the only kind of marriage, we are, indeed, early taught by our Bible-lessons. But though the conception of polygamy is thus made somewhat familiar, it does not occur to us that polyandry is also a possible arrangement; and we are surprised on first learning that it not only exists, but was once extremely general. When we contemplate these marital institutions unlike our own, we cannot at first imagine that they can be practised with a sense of propriety like that with which we practise ours. Yet Livingstone narrates that, in a tribe bordering one of the Central African lakes, the women were quite dis-

gusted on hearing that in England a man has only one wife. This is a feeling by no means peculiar to them.

"An intelligent Kandyan chief, with whom Mr. Baily visited these Veddahs, was perfectly scandalized at the utter barbarism of living with only one wife, and never parting until separated by death. 'It was,' he said, 'just like the wanderoos' (monkeys)."[1]

Again, one would suppose that, as a matter of course, monogamy, polygamy, and polyandry, in its several varieties, exhausted the possible forms of marriage. An utterly unexpected form is furnished us by one of the African tribes. Marriage, among them, is for so many days in the week—commonly for four days in the week, which is said to be "the custom in the best families:" the wife during the off days being regarded as an independent woman who may do what she pleases. We are little surprised, too, on reading that, by some of the hill-tribes of India, unfaithfulness on the part of the husband is held to be a grave offence, but unfaithfulness on the part of the wife a trivial one. We assume, as self-evident, that good usage of a wife by a husband implies, among other things, absence of violence; and hence it seems scarcely imaginable that in some places the opposite criterion holds. Yet it does so among the Tartars.

"A nursemaid of mine left me to be married, and some short time after she went to the Natchalnick of the place to make a complaint against her husband. He inquired into the matter, when she coolly told him her husband did not love her. He asked her how she knew he did not love her; 'Because,' she replied, 'he never whipped me.'"[2]

A statement which might be rejected as incredible, were it not for the analogous fact that, among the South African races, a white master who does not thrash his men is ridiculed and reproached by them as not worthy to be called a master. Among domestic customs, again, who, if he had been set to imagine all possible anomalies, would have hit upon that which is found among the Basques, and has existed among other races—the custom that on the birth of a child the husband goes to bed and receives the congratulations of friends, while his wife returns to her household work? Or who, among the results of having a son born, would dream of that which occurs among some Polynesian races, where the father is forthwith dispossessed of his property, and becomes simply a guardian of it on behalf of the infant? The varieties of filial relations and of accompanying sentiments continually show us things equally strange, and at first sight equally unaccountable. It seems hardly credible that it should anywhere be thought a duty on the part of children to bury their parents alive. Yet it is so thought among the Fijians; of whom we read also that the parents thus put out of the way, go to their graves with smiling

[1] Lubbock's "Prehistoric Times," p. 344 (first edition).

[2] Mrs. Atkinson's "Recollections of Tartar Steppes," p. 220.

faces. Scarcely less incredible does it seem that a man's affection should be regarded as more fitly shown toward the children of others than toward his own children. Yet the Hill-tribes of India supply an example:

"Among the Nairs every man looks upon the children of his sisters as his heirs. 'And he would be considered as an unnatural monster were he to show such signs of grief at the death of a child which . . . he might suppose to be his own, as he did at the death of a child of his sister.'"[1]

"The philoprogenitiveness of philosophical Europe is a strange idea, as well as term, to the Nair of Malabar, who learns with his earliest mind that his uncle is a nearer relation to him than his father, and consequently loves his nephew much more than his son."[2]

When, in the domestic relations, we meet with such varieties of law, of custom, of sentiment, of belief, thus indicated by a few examples which might be indefinitely multiplied, it may be imagined how multitudinous are the seeming incongruities presented among the social relations at large. To be made conscious of these, however, it is not needful to study uncivilized tribes, or alien races partially civilized. If we look back to the earlier stages of European societies, we find abundant proofs that social phenomena do not necessarily hang together in those ways which our daily experiences show us. Religious conceptions may be taken in illustration.

The grossness of these among civilized nations, as they at present exist, might, indeed, prepare us for their still greater grossness during old times. When, close to Boulogne, one passes a crucifix, at the foot of which lies a mouldering heap of crosses, made of two bits of lath nailed together, deposited by passers-by in the expectation of Divine favor to be so gained, one cannot but have a sense of strangeness on glancing at the adjacent railway, and on calling to mind the achievements of the French in science. Still more one may marvel on finding, as in Spain, a bull-fight got up in the interests of the Church —the proceeds being devoted to a "Holy House of Mercy!" And yet, great as seem the incongruities between religious beliefs and social states now displayed, more astonishing incongruities are disclosed on going far back. Consider the conceptions implied by sundry mystery-plays; and remember that they were outgrowths from a theory of the Divine government, which men were afterward burnt for rejecting. Payments of wages to actors are entered thus·

"Imprimis, to God, ij^{s}
Item, to Cayphas, iij^{s} iiij^{d}
. . . .
Item, to one of the knights, ij^{s}
Item, to the devyll and to Judas, xviij^{d}

[1] Quoted in McLennan's "Primitive Marriage," p. 187.
[2] Burton's "History of Sindh," p. 244.

"We have frequently such entries as: "Item, payd for the spret (spirit) of God's cote, ij^s.' We learn from these entries that God's coat was of leather, painted and gilt, and that he had a wig of false hair, also gilt."[1]

"Even the Virgin's conception is made a subject for ribaldry; and in the Coventry collection we have a mystery, or play, on the subject of her pretended trial. It opens with the appearance of the somnour, who reads a long list of offences that appear in his book; then come two 'detractors' who repeat certain scandalous stories relating to Joseph and Mary, upon the strength of which they are summoned to appear before the ecclesiastical court. They are accordingly put upon their trial, and we have a broad picture of the proceedings in such a case," etc.[2]

Again, on looking into the illuminated missals of old times, there is revealed to us a mode of conceiving Christian doctrine which it is difficult to imagine as current in a civilized or even semi-civilized society: instance the ideas implied by a highly-finished figure of Christ, from whose wounded side a stream of wafers spouts on to a salver held by a priest. Or take a devotional book of later date—a printed psalter, profusely illustrated with woodcuts representing incidents in the life of Christ. Page after page exhibits ways in which his sacrifice is utilized after a perfectly material manner. Here are shown vines growing out of his wounds, and the grapes these vines bear are being devoured by bishops and abbesses. Here the cross is fixed on a large barrel, into which his blood falls in torrents, and out of which there issue jets on to groups of ecclesiastics. And here, his body being represented in a horizontal position, there rise, from the wounds in his hands and feet, fountains of blood, which priests and nuns are collecting in buckets and jars. Nay, even more astonishing is the mental state implied by one of the woodcuts, which tries to aid the devotional reader in conceiving the Trinity, by representing three persons standing in one pair of boots![3] Quite in harmony with these astoundingly-gross conceptions are the conceptions implied in the popular literature. The theological ideas that grew up in times when Papal authority was supreme, and before the sale of indulgences had been protested against, may be judged from a story contained in the Folk-lore collected by the Brothers Grimm, called "The Tailor in Heaven." Here is an abridged translation:

"God, having one day gone out with the saints and the apostles for a walk, left Peter at the door of heaven with strict orders to admit no one. Soon after a tailor came and pleaded to be let in. But Peter said that God had forbidden any one to be admitted; besides, the tailor was a bad character, and 'cabbaged' the cloth he used. The tailor said the pieces he had taken were small, and had fallen into his basket; and he was willing to make himself useful—he would carry the babies, and wash or mend the clothes. Peter at last let him in, but made him sit down in a corner, behind the door. Taking advantage of

[1] Wright's "Essays on Archæology," vol. ii., pp. 175, 176. [2] ii., 184.

[3] But four copies of this psalter are known to exist. The copy from which I made this description is contained in the splendid collection of Mr. Henry Huth.

Peter's going outside for a minute or two, the tailor left his seat and looked about him. He soon came to a place where there were many stools, and a chair of massive gold and a golden footstool, which were God's. Climbing up on the chair, he could see all that was happening on the earth; and he saw an old woman, who was washing clothes in a stream, making away with some of the linen. In his anger, he took up the footstool and threw it at her. As he could not get it back, he thought it best to return to his place behind the door, where he sat down, putting on an air of innocence. God now reëntered, without observing the tailor. Finding his footstool gone, he asked Peter what had become of it—had he let any one in? The apostle at first evaded the question, but confessed that he had let in one—only, however, a poor limping tailor. The tailor was then called, and asked what he had done with the footstool. When he had told, God said to him: 'O you knave, if I judged like you, how long do you think *you* would have escaped? Long ago I should not have had a chair or even a poker left in the place, but should have hurled every thing at the sinners.' . . . ."[1]

These examples, out of multitudes that might be given, show the wide limits of variation within which social phenomena range. When we bear in mind that, along with theological ideas that now seem little above those of savages, there went (in England) a political constitution having outlines like the present, an established body of laws, a regular taxation, an emancipated working-class, an industrial system of considerable complexity, with the general intelligence and mutual trust implied by social coöperations so extensive and involved, we see that there are possibilities of combination far more numerous than we are apt to suppose. There is proved to us the need for greatly enlarging those stock-notions which are so firmly established in us by daily observations of surrounding arrangements and occurrences.

We might, indeed, even if limited to the evidence which our own society at the present time supplies, greatly increase the plasticity of our conceptions, did we contemplate the facts as they really are. Could we nationally, as well as individually, "see ourselves as others see us," we might find at home seeming contradictions, sufficient to show us that what we think necessarily-connected traits are by no means necessarily connected. We might learn from our own institutions, and books, and journals, and debates, that while there are certain constant relations among social phenomena, they are not the relations commonly supposed to be constant; and that, when from some conspicuous characteristic we infer certain other characteristics, we may be quite wrong. To aid ourselves in perceiving this, let us, varying a somewhat trite mode of representation, consider what might be said of us by an independent observer, living in the far future—supposing his statements translated into our cumbrous language.

"Though the diagrams used for teaching make every child aware that many thousands of years ago the earth's orbit began to recede

[1] "Kinder- und-Hausmärchen," by William and James Grimm, larger edition (1870), pp. 140–142.

from its limit of greatest eccentricity; and though all are familiar with the consequent fact that the glacial epoch, which has so long made a large part of the northern hemisphere uninhabitable, has passed its climax; yet it is not universally known that, in some regions, the retreat of glaciers has lately made accessible tracks long covered. Amid moraines and under vast accumulations of detritus, have been found here ruins, there semi-fossilized skeletons, and in some places, even records, which, by a marvellous concurrence of favorable conditions, have been so preserved that parts of them remain legible. Just as our automatic quarrying-engines occasionally turn up fossil cephalopods, so little injured that drawings of them are made with the sepia taken from their own ink-bags; so here, by a happy chance, there have come down to us, from a long-extinct race of men, those actual secretions of their daily life, which furnish coloring-matter for a picture of them. By great perseverance our explorers have discovered the key to their imperfectly-developed language; and in course of years have been able to put together facts yielding us faint ideas of the strange peoples who lived there during the last preglacial period.

"A report just issued refers to a time called by these peoples the middle of the nineteenth century of their era; and it concerns a nation of considerable interest to us—the English. Though until now no traces of this ancient nation were known to exist, yet there survived the names of certain great men it produced—one a poet whose range of imagination and depth of insight are said to have exceeded those of all who went before him; the other, a man of science, of whom, profound as we may suppose in many other respects, we know definitely this, that to all nations then living, and that have since lived, he taught how the Universe is balanced. What kind of people the English were, and what kind of civilization they had, have thus always been questions exciting curiosity. The facts disclosed by this report are scarcely of the kind anticipated. Search was first made for traces of these great men, who, it was supposed, would be conspicuously commemorated. Little was found, however. It did, indeed, appear that the last of them, who revealed to mankind the constitution of the heavens, had received a name of honor like that which they gave to a successful trader who presented an address to their monarch; and, besides a tree planted in his memory, a small statue to their great poet had been put up in one of their temples, where, however, it was almost lost among the many and large monuments to their fighting chiefs. Not that commemorative structures of magnitude were never erected by the English. Our explorers discovered traces of a gigantic one, in which, apparently, persons of distinction and deputies from all nations were made to take part in honoring some being—man he can scarcely have been. For it is difficult to conceive that any man could have had a worth transcendent enough to draw from them such extreme homage, when they thought so little of those by whom their name as a race

has been saved from oblivion. Their distribution of monumental honors was, indeed, in all respects remarkable. To a physician named Jenner, who, by a mode of mitigating the ravages of a horrible disease, was said to have rescued many thousands from death, they erected a memorial statue in one of their chief public places. After some years, however, repenting them of giving to this statue so conspicuous a position, they banished it to a far corner of one of their suburban gardens, frequented chiefly by children and nursemaids; and, in its place, they erected a statue to a great leader of their fighters—one Napier, who had helped them to conquer and keep down certain weaker races. The reporter does not tell us whether this last had been instrumental in destroying as many lives as the first had saved; but he remarks: 'I could not but wonder at this strange substitution among a people who professed a religion of peace.' Not, however, that this was an exceptional act, out of harmony with their usual acts: quite the contrary. The records show that, to keep up the remembrance of a great victory gained over a neighboring nation, they held for many years an annual banquet, much in the spirit of the commemorative scalp-dances of still more barbarous peoples; and there was never wanting a priest to ask on the banquet a blessing from one they named the God of love. In some respects, indeed, their code of conduct seemed not to have advanced beyond, but to have gone back from, the code of a still more ancient people from whom their creed was derived. One of the laws of this ancient people was, 'an eye for an eye, and a tooth for a tooth;' but sundry laws of the English, especially those concerning acts that interfered with some so-called sports of their ruling classes, inflicted penalties which imply that their principle had become 'a leg for an eye, and an arm for a tooth.' The relations of their creed to the creed of this ancient people are indeed difficult to understand. They had at one time cruelly persecuted this ancient people—Jews they were called—because that particular modification of the Jewish religion, which they, the English, nominally adopted, was one which the Jews would not adopt. And yet, marvellous to relate, while they tortured the Jews for not agreeing with them, they substantially agreed with the Jews. Not only, as above instanced, in the law of retaliation did they outdo the Jews, instead of obeying the quite opposite principle of the teacher they worshipped as divine, but they obeyed the Jewish law, and disobeyed this divine teacher in other ways—as in the rigid observance of every seventh day, which he had deliberately discountenanced. Though they were angry with those who did not nominally believe in Christianity (which was the name of their religion), yet they ridiculed those who really believed in it; for some few people among them, nicknamed Quakers, who aimed to carry out Christian precepts instead of Jewish precepts, they made butts for their jokes. Nay, more; their substantial adhesion to the creed they professedly repudiated was clearly demonstrated by this, that in each of their tem-

ples they fixed up in some conspicuous place the ten commandments of the Jewish religion, while they rarely fixed up the two Christian commandments which were to replace them. 'And yet,' says the reporter, after dilating on these strange facts, 'though the English were greatly given to missionary enterprises of all kinds, and though I sought diligently among the records of these, I could find no trace of a society for converting the English people from Judaism to Christianity.' This mention of their missionary enterprises introduces other remarkable anomalies. Being anxious to get adherents to this creed which they adopted in name, but not in fact, they sent out men to various parts of the world to propagate it—one part, among others, being that subjugated territory above named. There the English missionaries taught the gentle precepts of their faith; and there the officers employed by their government exemplified these precepts—one of the exemplifications being that, to put down a riotous sect, they took fifty out of sixty-six who had surrendered, and, without any trial, blew them from the guns, as they called it—tied them to the mouths of cannon, and shattered their bodies to pieces. And then, curiously enough, having thus taught and thus exemplified their religion, they expressed great surprise at the fact that the only converts their missionaries could obtain among these people were hypocrites and men of characters so bad that no one would employ them.

"Nevertheless, these semi-civilized English had their good points. Odd as must have been the delusion which made them send out missionaries to inferior races, who were always ill used by their sailors and settlers, and eventually extirpated by them, yet, on finding that they spent annually a million of their money in missionary and allied enterprises, we cannot but see some generosity of motive in them. They country was dotted over with hospitals and almshouses, and institutions for taking care of the diseased and indigent; and their towns were overrun with philanthropic societies, which, without saying any thing about the wisdom of their policy, clearly implied good feeling. They expended in the legal relief of their poor as much as, and at one time more than, a tenth of the revenue raised for all national purposes. One of their remarkable deeds was that, to get rid of a barbarous institution of those times, called slavery, under which, in their colonies, certain men held complete possession of others, their goods, their bodies, and practically even their lives, they paid down twenty millions of their money. And not less striking was the fact that, during a war between two neighboring nations, they contributed large sums, and sent out many men and women, to help in taking care of the wounded and assisting the ruined.

"The facts brought to light by these explorations are thus extremely instructive. Now that, after tens of thousands of years of discipline, the lives of men in society have become so harmonious—now that character and conditions have little by little grown into ad-

justment, we are apt to suppose that congruity of institutions, conduct, sentiments, and beliefs, is necessary. We think it almost impossible that, in the same society, there should be daily practised principles of quite opposite kinds; and it seems to us scarcely credible that men should have, or profess to have, beliefs with which their acts are absolutely irreconcilable. Only that extremely rare disorder, insanity, could explain the conduct of one who, knowing that fire burns, nevertheless thrusts his hand into the flame; and to insanity also we should ascribe the behavior of one who, professing to think a certain course morally right, pursued the opposite course. Yet the revelations yielded by these ancient remains show us that societies could hold together notwithstanding what we should think a chaos of conduct and of opinion. Nay, more, they show us that it was possible for men to profess one thing and do another, without betraying a consciousness of inconsistency. One piece of evidence is curiously to the point. Among their multitudinous agencies for beneficent purposes, the English had a 'Naval and Military Bible Society'—a society for distributing copies of their sacred book among their professional fighters on sea and land; and this society was subscribed to, and chiefly managed by, leaders among these fighters. It is, indeed, suggested by the reporter, that for these classes of men they had an expurgated edition of their sacred book, from which the injunctions to 'return good for evil,' and 'to turn the cheek to the smiter,' were omitted. It may have been so; but, if not, we have a remarkable instance of the extent to which conviction and conduct may be diametrically opposed, without any apparent perception that they are opposed. We habitually assume that the distinctive trait of humanity is rationality, and that rationality involves consistency; yet here we find an extinct race (unquestionably human, and regarding itself as rational) in which the inconsistency of conduct and professed belief was as great as can well be imagined. Thus we are warned against supposing that what now seems to us so natural was always natural. We have our eyes opened to an error which has been getting confirmed among us for these thousands of years, that social phenomena and the phenomena of human nature necessarily hang together in the ways we see around us."

Before summing up what has been said under the title of "Subjective Difficulties—Intellectual," I may remark that this group of difficulties is separated from the group of objective difficulties, dealt with in the last chapter, rather for the sake of convenience than because the division can be strictly maintained. In contemplating difficulties of interpretation—phenomena being on the one side and intelligence on the other—we may, as we please, ascribe failure either to the inadequacy of the intelligence or to the involved nature of the phenomena. The difficulty is subjective or objective according to our

point of view. But the difficulties above set forth arise in so direct a way from conspicuous defects of human intelligence, that they may be, more appropriately than the preceding ones, classed as subjective.

So regarding them, then, we have to beware, in the first place, of this tendency to automorphic interpretation; or rather, having no alternative but to conceive the natures of other men in terms such as our own feelings and ideas furnish, we have to beware of the errors likely hence to arise—discounting our conclusions as well as we can. Further, we must be on our guard against the two opposite prevailing errors respecting Man, and against the sociological errors arising from them: we have to get rid of the two beliefs that human nature is unchangeable, and that it is easily changed; and we have, instead, to become familiar with the conception of a human nature that is changed in the slow succession of generations by social discipline. Another obstacle not to be completely surmounted by any, and to be partially surmounted by but few, is that resulting from the want of intellectual faculty complex enough to grasp the extremely complex phenomena which Sociology deals with. There can be no complete conception of a sociological fact, considered as a component of Social Science, unless there are present to thought all its essential factors; and the power of keeping them in mind with due clearness, as well as in their proper proportions and combinations, has yet to be reached. Then beyond this difficulty, only to be in a measure overcome, there is the further difficulty, not, however, by any means so great, of enlarging the conceptive capacity, so that it may admit the widely divergent and extremely various combinations of social phenomena. That rigidity of conception produced in us by experiences of our own social life, in our own time, has to be exchanged for a plasticity that can receive with ease, and accept as natural, the countless different combinations of social phenomena utterly unlike, and sometimes exactly opposite to, those we are familiar with. Without such a plasticity there can be no proper understanding of coexisting social states allied to our own, still less of past social states, or social states of alien civilized races and races in early stages of development.

SPONTANEOUS MOVEMENTS IN PLANTS.

By ALFRED W. BENNETT, M. A., B. Sc., F. L. S.

THAT there are no "hard and fast lines" in Nature is a truth which is more and more forcing itself upon the minds of men of science. The older naturalists delighted to circumscribe their own special domains within sharply-marked boundaries, which no trespassers were allowed to pass. We have long given up the attempt thus

accurately to map out the kingdom of Nature. Her varied productions are connected with one another by innumerable links and cross-links; and our systems of classification, even the most "natural," are but an imperfect human contrivance for bringing together those forms which present the most evident marks of resemblance or affinity. While the truth of this law is most familiar in the case of those smaller subdivisions of the animal and vegetable kingdoms—classes, orders, and genera—which are connected with one another by innumerable intermediate forms, it is none the less certain in the line of demarcation which separates these two great kingdoms themselves from one another. In attempting to draw up a definition which shall serve accurately and infallibly to distinguish between the Animal and Vegetable Kingdoms, we find ourselves compelled to abandon one supposed crucial test after another, and to content ourselves at last with framing, as in the case of the lower subdivisions, an assemblage of characters, by the *tout-ensemble* of which we must decide whether our organism is an animal or a plant. So great is the uncertainty as to the actual boundary-line, that large groups of lowly organisms, such as those known as Diatoms and Desmideæ, have been regarded by experienced authorities as belonging to each kingdom; and one of the ablest of living naturalists, Ernst Haeckel, of Jena, has proposed the division of the material universe not into three but into four kingdoms—animals, plants, protista, and minerals, the new kingdom of Protista including the most lowly-organized forms of what are generally considered animals and plants, from the Flagellate Infusoria to the Fungi, distinguished by the absence of sexes, and the mode of reproduction by gemmation or fission alone. The soundness of this new classification is not, however, admitted by the best remaining authorities in England or Germany.

One of the most obvious distinctions between the Animal and Vegetable Kingdoms consists in the possession by the former of a power of voluntary motion of either the whole or a part of the body, dependent on the presence of a distinct nervous system, which is absent in the latter; a distinction obvious enough when contrasting any of the higher forms of the two kingdoms, but which, like all other individual characters, fails when pressed to too rigid a test. There are animals, so regarded by the best naturalists, and possessing other characters which compel us to refer them to this class, whose power of motion is confined to the "contractility" common to all protoplasmic substance, and which are absolutely devoid of a nervous system; and there are plants, unquestionable plants, which possess powers of spontaneous motion strictly comparable to those exhibited by the lower animals. It may be interesting to collect together a few illustrations of this last-named fact, some of which appear to the writer scarcely explicable by the application of any of those laws which govern inert unorganized matter.

The movements to which reference is here made belong in most cases to a part rather than to the whole of a plant; in some cases, however, we find the whole organism endowed with spontaneous motion of a very remarkable character. An instance of this occurs in the case of the regular undulating motion, exceedingly similar to that of some of the lower animals, characteristic of a class of Algæ hence called Oscillatoriæ. The mode of reproduction of the Algæ, the lowest class of the vegetable kingdom, to which the sea-weeds and the fresh-water confervæ belong, is often obscure, and in some cases different distinct processes exist in the same species. In certain fresh-water Algæ, reproduction takes place by the formation of "Zoospores" (Fig. 1), which are the results of the separation and isolation of the protoplasmic contents of certain special cells. According to the observations of M. Thuret, who has paid great attention to this subject, these zoospores, which are of extreme minuteness, are ovoid in form, and are furnished, either over their whole circumference or toward one extremity, with very fine cilia, varying from two to a large number. As soon as these minute bodies free themselves from the cell in which they are enclosed, the cilia begin to vibrate with great rapidity, the vibration being accompanied by a movement of rotation of the bodies themselves on their axis, occasioned apparently by rapid and spontaneous contractions; the result being a quick motion of the body through the water —undistinguishable, in fact, from that of some of the lower forms of

FIG 1.

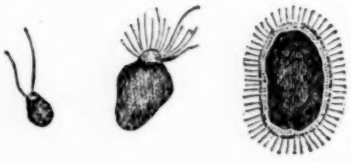
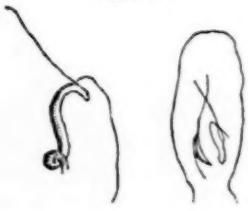


FIG. 2.



animal life—continuing for a period varying from half an hour to several hours, at the expiration of which they settle down, reassume the characters of ordinary vegetable cells, lose their cilia, and give rise, by cell-division, to new individuals resembling the parent-plant. Those zoospores which are furnished with cilia at one extremity only, direct that extremity, which is destitute of chlorophyll or green coloring-matter, toward the light. Closely resembling these zoospores are the "spermatozoa" of the higher orders of cryptogamic plants, ferns, equisetums, and mosses. These bodies (Fig. 2) are produced in the antheridia or male organs, again by a modification of the protoplasmic cell-contents; they are filiform bodies of various forms, mostly presenting one or more spiral curves, and furnished with vibratile cilia. When released from the parent-cells, they move about with great ac-

tivity until they come into contact with the opening of the archegonium or female organ, which they enter, and thus fructify the germ of the new plant. Pringsheim describes the process by which the spermatozoa enter the archegonium as a very peculiar twisting motion, due to the action of the mucus or protoplasm of the germ-cell. He has seen a large number of spermatozoa enter a single cell, forming a kind of chain.

In describing these curious bodies, of the connection of which with the vegetable kingdom there is no room for doubt, one is irresistibly reminded of these lowly forms of animal life known as *Amœba* and *Gromia*, consisting apparently of shapeless masses of protoplasm possessing indeed far more restricted powers of locomotion than the zoospores and spermatozoa, their faculties in this respect being confined to the protrusion and retractation of arms or pseudopodia, by means of which a slow movement is effected. If the possession of consciousness and of a voluntary control over the movements of the body belongs to the animal kingdom even to its lowest forms, it is difficult to frame any cogent reason for denying these faculties to the vegetable organisms which we have been considering. A very interesting problem also presents itself for solution in the almost perfect identity of constitution between these lowest forms of animals and the protoplasmic elements in the constitution of more highly-organized forms. If the *Amœbæ* and *Gromiæ* are admitted to be distinct individual animals, the same line of reasoning would almost compel us to admit to the same rank the white corpuscles of the blood of mammalia, which present almost the same characters and possess the same power of protrusion and retractation of a portion of their substance.

The instances above cited illustrate the faculty of spontaneous motion possessed by detached portions of protoplasm endowed with the power of forming themselves into new individuals. This phenomenon appears, however, to be but a form of the property possessed by all protoplasm, of constant motion in some form or other. The circulation of the protoplasmic mucous fluid within the cells of plants is one of the most beautiful phenomena of vegetable life revealed by the microscope, and one of which the explanations at present offered appear quite inadequate. A favorite object for exhibiting this circulation or rotation is formed by the jointed hairs which cover the stamens of the Virginian spider-wort (*Tradescantia Virginica*). The movement is rendered visible by the presence, in the otherwise colorless fluid, of minute opaque granules of chlorophyll or other coloring-matter; and is observable with great ease in the semi-transparent tissue of certain water-plants, as *Chara*, or the *Valisneria* commonly grown in fresh-water aquariums. It consists of a slow movement of the protoplasmic fluid up one side of the cell, across the ends, and down the other side; not perpendicularly, but in an oblique or spiral course. The subject has been carefully investigated by three French physiologists, MM.

Prillieux, Roze, and Brogniart, who find that the rotation is directly influenced, in a remarkable manner, by the presence of light. M. Prillieux kept a moss in the dark for several days, when the cells presented the appearance of a green net-work, between the meshes of which was a clear, transparent ground. All the grains of chlorophyll were applied to the walls which separate the cells from one another; there were none on the upper or under walls which form the surfaces of the leaf. Under the influence of light, the grains, together with the thin mucous plasma in which they are embedded, change their position from the lateral to the superficial walls, this change taking place, under favorable circumstances, in about a quarter of an hour. On attaining their new position, the grains do not remain absolutely immovable, but continually approach and recede from one another; and, if again darkened, they leave their new position, and return to the lateral walls. Artificial light produces the same effect as daylight.

Analogous to the circulation of the protoplasm, within the cell, is that of the sap or nutritive fluid through the whole plant, passing through the permeable walls of the cells. This circulation of the sap, by which fluid is conveyed equally to all parts of the plant, apparently in opposition to the laws of gravity, is no doubt explicable, to a certain extent, by the application of known physical laws, of which the most important are capillary attraction, osmose, or the law by which a less dense fluid passes through a permeable diaphragm to mingle with a denser fluid, and the upward-pumping force, to supply the partial vacuum occasioned by the evaporation of water from the leaves. Allowing, however, full scope to all these physical forces, there would seem to be a residuum of energy, still unaccounted for, connected with the vitality of the plant itself. In particular, the selective power of plants, in absorbing from the soil a larger portion of those ingredients which are required for the formation, or healthy life, of their tissues, is an absolutely unexplained phenomenon. A familiar instance of this is furnished by the difference in the amount of silica absorbed by corn-crops and by leguminous plants, amounting, in the former case, to 2.5 per cent., in the latter, to 0.3 per cent., of the dry foliage. Indeed, if any two plants are grown together, side by side, in the same soil, the constitution of the ash, i. e., of the solid ingredients derived from the soil, will be remarkably different; while, in the same plant, in the same soil, the constitution is constant. It was pointed out, by the Duke of Argyll, when criticising Darwin's "Origin of Species," how unavoidable it seems, in describing the phenomena of Nature, to use language involving the idea of contrivance and design. In the same manner, it seems impossible to describe the process of vegetative life without appearing to attribute to the plant some conscious power of its own. A striking instance of this, as well as of the liability to consider a mere statement of an obscure law in other terms as an explanation of that law, occurs in an admirable treatise on the growth of plants—

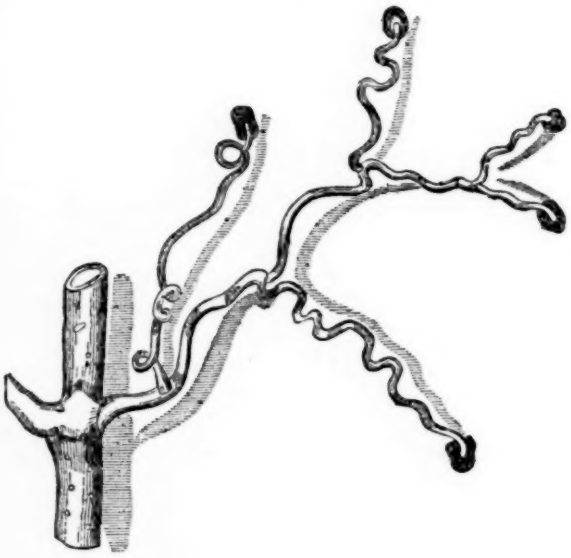
Johnson's "How Crops Grow."[1] "The cereals *are able to dispose* of silica by giving it a place in the cuticular cells; the leguminous crops, on the other hand, *cannot remove it* from their juices; the latter remain saturated, and thus further diffusion of silica from without becomes impossible except as room is made by a new growth. It is in this way that we have a *rational and adequate* explanation of the selective power of the plant." The "rational and adequate explanation" seems to me, on the contrary, to be merely a restatement of this selective power of the tissues in other terms. Because the tissues want the silica, is no explanation of how they get it.

The curious and interesting movements of climbing plants have been investigated by Palm, Mohl, and Asa Gray, and form the subject of one of the most charming of Mr. Darwin's works. It is well known that climbing plants, such as the hop, honeysuckle, or major convolvulus, always twine round the stem or other object which supports them in one direction, that is, always either from right to left or from left to right; but few, probably, have reflected, and fewer still attempted to observe, by what process the end of the growing shoot contrives to change its position from one side to the other of the stem. If the extremity of a living stem, say of convolvulus, growing perfectly free, and in a normal position, is observed, it is seen to hang over from its support in a horizontal direction; and this horizontal portion is found, if observed at intervals of some hours, to point in different directions. The end of the growing shoot has, in fact, the property of revolving in a large circle, round the support, always, with the same species, in the same direction, either with the sun or opposed to the sun. The rate of revolution varies with different plants, and with the same plant at different periods of its growth; it is much quicker in warmer than in cooler weather. With the hop, Darwin found it to vary from two and a half hours to nine hours. The object of the climbing power of plants is no doubt to reach the light, and to expose a large surface of leaves to its action and to that of the free air; but the mode by which this power of motion is gained is by no means clear. The late eminent physiologist Mohl supposed that it was caused by a dull kind of irritability in the stem, which caused it to bend toward the support when in contact with it. Mr. Darwin has, however, carefully tested this theory experimentally, and always with negative results. He rubbed many shoots, much harder than was necessary to excite movement in any tendril, or in any foot-stalk, of a leaf-climber, but without result. This view seems also entirely negatived by the fact that not only do the stems of climbing plants revolve when they are not in contact with any support, but even more freely, under such circumstances, than

[1] "How Crops Grow:" A Treatise on the Chemical Compositions, Structure, and Life, of the Plant, for Agricultural Students. By S. W. Johnson. Revised and adapted for English Use, by A. H. Church and W. T. T. Dyer. London: Macmillan & Co., 1869 pp. 345.

when climbing. When a climbing plant first springs from the ground, the extremity of the shoot performs slow gyrations in the air, as if, as Darwin expresses it, it were *searching* for a support. I do not here discuss the question whether this habit may be the result of a tendency transmitted and enhanced through thousands of generations; the movement itself is, in the individual plant, entirely "spontaneous," in every sense of the term; that is, is not the necessary result of known physical laws acting upon the individual. Darwin's paper, "On the Movements and Habits of Climbing Plants," published in the *Journal of the Linnæan Society*, contains a number of the most interesting observations on this class of plants; and the language employed is everywhere suggestive of some hidden, sentient controlling power in the plant itself.

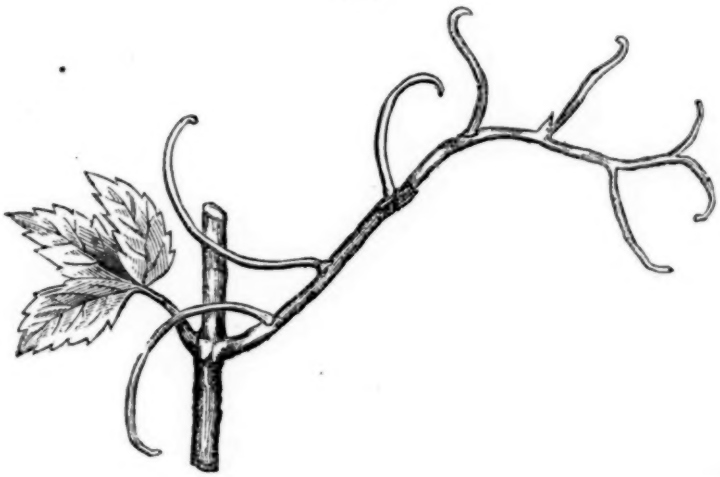
FIG. 3.



The same purpose as that served by a climbing stem is answered in other plants, as the vine, Virginian creeper, and passion-flower, by tendrils; and the phenomena of spontaneous motion in tendrils are, if possible, still more curious. Some tendrils display the same power of rotatory motion possessed by the extremities of the shoots of climbing plants; others do not revolve, but are sensitive, bending to the touch. The curling movement, consequent on a single touch, continues to increase for a considerable time, then ceases; after a few hours the tendril uncurls itself, and is again ready for action. A tendril will thus show a tendency to curl round any object with which it comes into contact, with the singular exception that it will seldom twine itself round another tendril of the same plant. It is also very curious that,

with some exceedingly sensitive plants, the falling of drops of rain on the tendril will produce no effect whatever. The mode in which a tendril of a *Bignonia* catches hold of a support is thus described by Darwin: "The main petiole is sensitive to contact with any object; even a small loop of thread after two days caused one to bend upward. The whole tendrils are likewise sensitive to contact. Hence, when a shoot grows through branched twigs, its revolving movement soon brings the tendril into contact with some twig, and then all three

FIG. 4.



'toes' bend (or sometimes one alone), and, after several hours, seize fast hold of the twig, exactly like a bird when perched." The Virginian creeper has another mode of attaching itself to a wall or other solid support, by the formation, at the extremities of the branches of the tendril, of little disks or cushions, very similar to the disks on the foot of the house-fly, by which it is enabled to attach itself to our windows, and to walk along the ceiling. These disks secrete a glutinous fluid, which attaches the tendril to the support with such strength that it is often impossible to detach it without destroying the tendril, or even removing a portion of the wall itself. As soon as the attachment is accomplished, the tendril gradually thickens, and contracts spirally, as shown in Figs. 3 and 4. This spiral contraction, indeed, is always the result of the tendril meeting with a support; and, if no support is found, the tendril soon shrinks and withers away. Some tendrils exhibit a most remarkable power of selection, which, to use Mr. Darwin's words, "would, in an animal, be called instinct." The tendrils of a species of *Bignonia* slowly travelled over the surface of a piece of wood, and, when the apex of one of them came to a hole or fissure, it inserted itself; the same tendril would frequently withdraw from one

hole and insert its point into a second one. Mr. Darwin has seen a tendril keep its point, in one instance, for twenty hours, and, in another instance, for thirty-six hours, in a minute hole, and then withdraw it. After the record of this fact on such unexceptional evidence, we are the more prepared to credit the statement of Mr. Anderson-Henry, that a climber will, in running up a wall, carefully avoid contact with another climber which it dislikes; and even the account by M. Paul Lévy,[1] that the *lianes* of tropical forests have an affinity for certain trees, toward which they direct their growth, and not toward those nearest to them; carefully drawing themselves away when they encounter one of the objectionable trees.

We may conclude our account of climbing plants with the following remarks by Mr. Darwin: "It has often been vaguely asserted that plants are distinguished from animals by not having the power of movement. It should rather be said that plants acquire and display this power only when it is of some advantage to them, but that this is of comparatively rare occurrence, as they are affixed to the ground, and food is brought to them by the wind and rain. We see how high in the scale of organization a plant may rise, when we look at one of the more perfect tendril-bearers. It first places its tendrils ready for action, *as a polypus places its tentacula.* If the tendril be displaced, it is acted on by the force of gravity, and rights itself. It is acted on

Fig. 5.

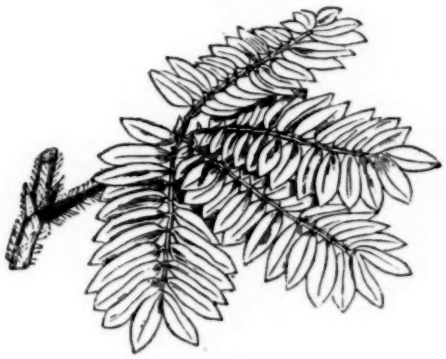
by the light, and bends toward or from it, or disregards it, whichever may be most advantageous. During several days the tendrils or internodes, or both, spontaneously revolve with a steady motion. The tendril strikes some object, and quickly curls round, and firmly grasps

[1] Bulletin de la Société Botanique de France. Translated in the *Gardener's Chronicle*, March 19, 1870.

it. In the course of some hours it contracts into a spire, dragging up the stem, and forming an excellent spring. All movements now cease. By growth, the tissues become wonderfully strong and durable. The tendril has done its work, and done it in an admirable manner."

The phenomenon known as Sensitiveness is of by no means uncommon occurrence in the vegetable kingdom. It consists of a sudden movement of the leaf, a portion of the flower, or the whole plant, on contact with, or even on the approach of, a foreign body. One of the most familiar examples is that of the Sensitive-plant (*Mimosa pudica* and *sensitiva*), Figs. 5 and 6, in which three distinct movements are

FIG. 6.



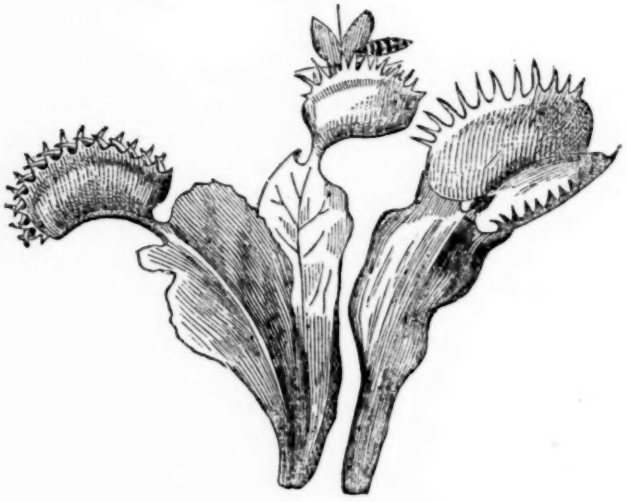
observable when the leaf is touched by the hand or the warm breath. First, the numerous leaflets close in pairs, bringing their upper faces together, and also inclining forward; then the four branches of the leaf-stalk, which were outspread like the rays of a fan, approach each other; at the same time the main leaf-stalk turns downward, bending at its joint with the stem. The explanation offered in one of our best botanical text-books, of this phenomenon, is as follows: "There is a swelling at the base of the petiole, the cells of which constitute, as it were, two springs acting in contrary directions, so that, if the one from any cause be paralyzed, the other pushes the leaf in the direction of least resistance. These springs, if they be so called, are set in action by the rush of fluid creating a turgid state of the one set of cells and an empty state of the other. What circumstances regulate the turgescence are only imperfectly known." It will be obvious that, even if this is correct as a statement of facts, it offers no real explanation of the phenomenon; for it is quite as difficult to understand how the mere approach of the hand, which gives rise to a sensitiveness commencing, it will be remarked, at the *extremity* of the leaf, will account for a "turgescence" of the springs at the *base* of the leaf, which then causes the movement. It should be observed also that we are unaware of any use which these movements are to the plant. Similar sensitiveness

occurs in the leaves of some other leguminous plants, in several species of *Oxalis*, etc. M. Bert has observed that the sensitiveness is destroyed by the continual application of chloroform, and also by placing the plant constantly in the dark or in green light.

Similar movements to that of the Sensitive-plant, but occurring spontaneously, may be observed in other plants. Thus in the *Desmodium gyrans* or "Telegraph-plant," sometimes grown in our hot-houses, belonging to the same order, Leguminosæ, the leaf consists of three leaflets, a large central, and two smaller side ones. The motion is especially observable in the small side-leaflets, which on a warm summer's day may be seen to rise and fall by a succession of jerking movements; now stopping for some time, then moving briskly, always resting for a while in some part of their course, and starting again without apparent cause, "seemingly of their own will," as Prof. Asa Gray remarks. The movement is not simply up and down, but the end of the moving leaflet sweeps more or less of a circuit. It is not set in motion by a touch, but begins, goes on, and stops, of itself.

An exceedingly remarkable instance of sensitiveness occurs in the case of the "Venus's Fly-trap" of North Carolina (*Dionæa muscipula*),

FIG. 7.



represented in Fig. 7. The mid-rib of each leaf serves as a kind of hinge. When the inside of the blade of the leaf, or the fine bristles which grow on its surface, are touched by any foreign substance, the hinge suddenly closes, and if the intruding substance be a fly or other small object, it is immediately imprisoned as represented in the figure, the teeth on the margin of the leaf closing firmly upon one another like a steel trap, the sides of the trap then flatten down and press firmly

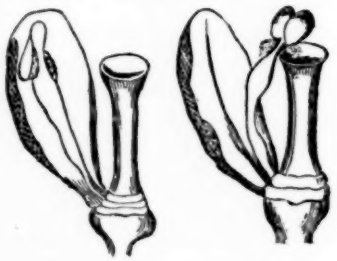
upon the victim, and it now requires a very considerable force to open the trap. If nothing is caught, the trap presently reopens of itself, and is ready for another attempt. With regard to the object of this strange proceeding, there can be no doubt that the insect is retained until the softer parts of the body are completely dissolved in the thick mucous fluid which is exuded by the leaves; and Prof. Asa Gray considers that the evidence is nearly complete that the animal matter is actually absorbed in the leaf itself. It is even stated that pieces of raw beef are digested by the leaf in the same manner! Seeing, however, that it is now generally admitted by physiologists that even pure water is not absorbed through the pores of leaves, which serve only for the *exhalation* of vapor, this explanation is very hard of belief. The "pitchers" of the *Nepenthes*, or pitcher-plant, act also as fly-traps, large numbers of insects being enticed into them by the fluid they secrete, and are then unable to extricate themselves.

The sensitiveness of the leaves of plants is but an excessive development of the phenomenon known as the Sleep of Plants. In the case of the Sensitive-plant the position assumed by the leaf and leaflets in the night is the same as that which they assume when disturbed in the daytime; and with many other plants, such as the clover and the *Robinia* or "acacia" tree, the change in the position of the leaflets, morning and evening, is a familiar fact. The Sleep of Plants extends also to the flowers, many plants opening their flowers only at particular times of the day. Thus the major convolvulus of the gardens and the goat's-beard open at sunrise and always close by about noon, the evening primrose opens only in the evening, and many others last for but a single day. So regular is the time of opening and closing of some flowers, that Linnæus drew up a list, which he termed a "floral clock." The singular part of the affair is, that with many flowers the time of opening and closing is determined, not by the degree of light, or by the temperature or humidity of the atmosphere, but absolutely by the hour of the day. The giant water-lily of the Amazons, the *Victoria regia*, opens, for the first time, about 6 P. M., and closes in a few hours, then opens again at 6 P. M. the next day, remaining open until the afternoon, when it closes and sinks below the water. Other plants, again, open their flowers only in the bright sunshine, as the beautiful yellow centaury (or *Chlora perfoliata*) the sundew (*Drosera rotundifolia*), etc. In the latter plant, belonging to the same natural order as the Venus's Fly-trap, and possessing a slight irritability of the leaves, Mr. Worthington Smith has noticed also a strong sensitiveness in the petals, the flowers closing suddenly when touched.

Irritability or sensitiveness, similar to that of the leaves of the Sensitive-plant, is not uncommon in the flower. An instance has been alluded to in the petals of the sundew; it occurs also in the lip of the corolla of several of the orchis tribe. It is, however, more common in the proper organs of reproduction, as the style of *Stylidium*, the sta-

mens of the berberry, etc., and is then directly connected with the process of fertilization of the ovule. In *Stylidium*, an Australian genus, the style and filaments are adherent into a column, which hangs over on one side of the flower. When touched, it rises up and springs over to the opposite side, at the same time opening its anthers and scattering the pollen. The stamens of the various species of *Berberis* and *Mahonia*, to the former of which our common berberry belongs, exhibit this irritability to a remarkable degree. If touched with a pin or other object at the base of the inside face of the filament, the stamen will spring violently forward from its place within the petal, so as to bring

FIG. 8.



the anther into contact with the stigma, as shown in Fig. 8, and will after a time slowly resume its original position. At first sight it may seem as if this contrivance were intended to insure the fertilization of the pistil from the pollen of its own flower. In reality, however, the reverse is the case; the excitation takes place in Nature when an insect entering the flower, for the sake of the honey in the glands at the base of the pistil, touches the inside of one of the stamens. The pollen is thus thrown on to the head or body of the insect, which carries it away to the next flower it visits, and leaves some of it on the stigma, and thus cross-fertilization instead of self-fertilization is secured. Similar motion of the stamens toward the pistil, but spontaneous, takes place in the case of the London Pride, and other species of *Saxifraga*.

Elasticity is, indeed, a common property of organized tissue, though it is not often developed to so evident an extent. In the "touch-me-not," or *Impatiens*, we have a familiar instance in the seed-vessel, which, if touched when nearly ripe, suddenly coils back, throwing the seeds to a considerable distance. The "squirting cucumber" (*Momordica elaterium*) marks the period of ripeness by the fruit separating from its stalk, and expelling the seeds and juice with great violence. Mr. Thomas Meehan described a remarkable instance of elasticity at a recent meeting of the Academy of Natural Sciences of Philadelphia. The seeds—or, as would appear from his description, more correctly the embryos of the seeds—of the American "witch-hazel" (*Hamame-*

lis Virginica) are thrown out with such force as to strike people violently in the face who pass through the woods. Collecting a number of the capsules, and laying them on the floor, he found the seeds or embryos were thrown out generally to the distance of four or six feet, and in one instance as much as twelve feet.

Many of the instances of spontaneous motion or irritability we have now recorded may doubtless be explained by the application of known physical laws. With others this is not so easy; and it is but reasoning in a circle to say that, because the organisms which manifest them belong to the vegetable kingdom, therefore the phenomena cannot be the result of a sentient force acting upon, and independent of, matter. Darwin has described how certain movements of the tendrils of climbing plants would be termed instinctive if they were observed in animals. The rapid rotatory motion of the zoospores of the lower Algæ is absolutely undistinguishable from that of certain undoubted lowly organized forms of animal life. It is very difficult to distinguish between the movement of a shoot of a climber performing its circles in the air in search of a support, and that of the tentacula of a coral-polyp in search of food. The mode in which the Venus's Fly-trap seizes and encages its prey is very like that adopted by a sea-anemone. Every fresh addition to our knowledge seems to confirm us in the view that it is unwise to dogmatize by laying down too rigid generalities, and absolutely to deny certain functions to whole classes of animated beings because we do not find them exhibited in the forms most familiar to us. I do not wish distinctly to claim for plants the actual possession of a voluntary or sentient faculty. But I do wish to point out that facts do not support us in asserting that a clear line of demarcation separates the animal from the vegetable kingdom; the power of voluntary motion belonging to the one and not to the other. Taking all the facts we have described into consideration, the statement seems justified which has been made by one of our most experienced naturalists, Prof. Wyville Thomson: "There are certain phenomena, even among the higher plants, which it is very difficult to explain without admitting some low form of a general harmonizing and regulating function, comparable to such an obscure manifestation of reflex nervous action as we have in sponges and in other animals in which a distinct nervous system is absent."—*Popular Science Review.*

LIGHT AND LIFE.

By FERNAND PAPILLON.

TRANSLATED FROM THE FRENCH BY A. R. MACDONOUGH, ESQ.

THE organized being that we observe on the surface of the globe does not subsist solely by the nourishment absorbed, sometimes in the form of aliment, sometimes in that of atmospheric air; it needs besides, heat, electricity, and light, which are like a secret and life-giving spring for the world. Its organs are subject to the twofold influence of an inner medium, represented by the humors moistening its tissues, and of an outer medium, composed of all those subtle and fluid agents with which space is filled. This close interdependence of beings and of the media in which they are immersed, too plain to have quite escaped notice, yet too complex for analysis by science in its infancy, has been brought in our day under piercing and methodical investigation, yielding results of remarkable interest. Light especially takes a part in this combination deserving deep study. Whether organic existence in its simplest expression and its lowest degree be considered, or whether we regard it in its highest functions, the influence of light upon it strikes us in the most strange and unlooked-for relations. Lovely forms and vivid colors, the hidden harmonies of life as well as its dazzling brightness and bloom, alike claim mysterious connection with that golden mist diffused by the sun over the world.

From this point of view, modern science finds reason in the simple worship paid by primitive man. It helps us to understand the divine honors given to the star of day among the earliest civilized nations, and the pathetic terror those child-like races suffered when, at evening, they saw the crimson globe, that was the source for them of all power and all splendor, slowly disappear in the horizon. That pious idolatry, far from being a mere utterance of gratitude for the wealth of fertility scattered by the sun over earth, was a homage, too, to the comforting source of brightness and joy, revealing the natural affinity between man and light. The Vedas, the Orphic hymns, and other remains of the earliest religions, are full of this feeling, which appears again in many poets and philosophers of antiquity, Lucretius and Pliny among others. Dante, invoking so often "the divine and piercing light," crowns his poem by a hymn which more than any thing else is a symbolic description of the supreme brightness. On the other hand, laborers, gardeners, physicians, unite in bearing witness to the beneficial effects of light. Naturalists and philosophers, too, in all ages, impressed with the power of the sun, have described its manifold effects. Alexander Humboldt, following Goethe and Lavoisier, often notices its its various influences. Yet it was not until the middle of the eighteenth

century that so rich a subject of study began to attract serious experimental research; and such are the difficulties of this grand and complex problem, that its solution is only partly revealed, in spite of a long series of attempts. Great deficiencies remain to be supplied, and many vaguely-known points to be cleared up, nor has an effort even been made as yet to systematize all the groups of results gained. The latter task we propose to attempt here, with the purpose of showing by a remarkable instance the manner of evolving knowledge through the power of the experimental method, the sequent, cumulative, and mutually-supporting character of well-conducted experiments, and their endless wealth of instruction; in a word, the process adopted by eminent men in the great art of wresting her secrets from living Nature.

I.

Plants gain their nourishment by the absorption through their roots of certain substances from the soil, and by the decomposition, through their green portions, of a particular gas contained in the atmosphere—carbonic-acid gas. They decompose this gas into carbon, which they assimilate, and oxygen, which they reject. Now, this phenomenon, which is the vegetable's mode of respiration, can only be accomplished with the assistance of solar light.

Charles Bonnet, of Geneva, who began his career by experimenting on plants, and left this attractive subject, to devote himself to philosophy, only in consequence of a serious affection of his sight, was the first to detect this joint work, about the middle of the eighteenth century. He remarked that vegetables grow vertically, and tend toward the sun, in whatever position the seed may have been planted in the earth. He proved the generality of the fact that, in dark places, plants always turn toward the point whence light comes. He discovered, too, that plants immersed in water release bubbles of gas under the influence of sunlight. In 1771, Priestley, in England, tried another experiment. He let a candle burn in a confined space till the light went out, that is until the contained air grew unfit for combustion. Then he placed the green parts of a fresh plant in the enclosure, and at the end of ten days the air had become sufficiently purified to permit the relighting of the candle. Thus he proved that plants replace gas made impure by combustion with a combustible gas; but he also observed that at certain times the reverse phenomenon seems to result. Ten years later, the Dutch physician, Ingenhousz, succeeded in explaining this apparent contradiction. "I had but just begun these experiments," says that skilful naturalist, "when a most interesting scene revealed itself to my eyes: I observed that not only do plants have the power of clearing impure air in six days or longer, as Priestley's experiments seem to point out, but that they discharge this important duty in a few hours, and in the most thorough way; that this singular operation is not due at all to vegetation, but to the effect of sunlight; that it does

not begin until the sun has been some time above the horizon; that it ceases entirely during the darkness of night; that plants shaded by high buildings or by other plants do not complete this function, that is, they do not purify the air, but that, on the contrary, they exhale an injurious atmosphere, and really shed poison into the air about us; that the production of pure air begins to diminish with the decline of day, and ceases completely at sunset; that all plants corrupt the surrounding air during the night, and that not all portions of the plant take part in the purification of the air, but only the leaves and green branches."

How do this transformation of impure air into pure air under the influence of sunlight, and the reverse process during darkness, take place? Senebier, the countryman and friend of Bonnet, gives us the answer. Applying to the problem the late discoveries of Lavoisier, he showed that the impure air absorbed and decomposed in the daytime by plants is nothing more than the carbonic acid thrown off by a burning candle or a breathing animal, and that the pure air which results from this decomposition is oxygen. He proved besides that the gas released by vegetables during the night is also carbonic acid, and consequently that the respiration of plants in the night-time is the reverse of that in the daytime. He also demonstrated that heat cannot supply the place of light in these processes. Thus the nature of the phenomenon was explained, but it remained to be learned what relation exists between the volume of carbonic acid absorbed and that of the oxygen released. Another Genevese, Theodore de Saussure, proved that the quantity of oxygen released is less than that of carbonic acid absorbed, and at the same time that a part of the oxygen retained by the plant is replaced by nitrogen thrown off; and supposed that this nitrogen was furnished by the substance of the plant itself. This function of the green portions of vegetables is, moreover, performed with great rapidity and energy. Boussingault, who has made some remarkable experiments on this subject, filled a vessel of water with vine-leaves, placed it in the sun, and sent a current of carbonic acid through it; on its passing out, he collected nothing but pure oxygen. It is calculated that a leaf of nenuphar gives out in this way during the summer more than 66 gallons of oxygen.

In 1848 Cloëz and Gratiolet contributed new facts. They showed that aquatic plants follow the same course during the day as others, but that at night they are at rest, and give rise to no release of carbonic acid. They proved the powerful, instantaneous action of solar light on vegetable respiration. If a few leaves of *potamogeton* or of *nayas* are put into a gauge full of water saturated with carbonic acid, as soon as the apparatus is placed in the sun, an immense number of light bubbles, of almost pure oxygen, are seen to detach themselves from the surface of the leaves. The shadow of a slight cloud, crossing the sky, suffices to check their disengagement at once, followed by

sudden activity after it has passed. By intercepting the solar beam with a screen, the alternations of quickness and slowness in the production of gas-bubbles may be very plainly seen, according as the plant receives the rays or not. Water-plants show other interesting peculiarities. Diffused light has no power to excite the production of carbonic acid, unless the phenomenon has been first called forth by direct sunlight. Still further, the solar influence having once been applied, the evolution of carbonic acid continues even in darkness. The vegetable keeps up at night its mode of breathing by day. The living force of solar light, therefore, can be fixed and stored away in living plants, as Van Tieghem, the discoverer of this curious property, very well remarks, to act afterward in complete darkness, and exhaust itself by slow degrees, through transformation into equivalent chemical energy. It appears to lodge itself in phosphorescent sulphur, to reappear under the form of less intense radiations; it hoards itself up in paper, starch, and porcelain, to come forth anew, after a greater or less lapse of time, through its action on the salts of silver. The peculiarity residing in these green cells of vegetables, then, is not an isolated one: it is a special instance of the general property, inherent in many bodies, of retaining, within their mass, in some unknown form, a part of the vibrations that fall upon them, and of preserving them through transformation, to be afterward emitted, either in the state of luminous radiations, or in the condition of chemical or mechanical energy. The great principle of the transformation of forces thus holds good in the vegetable kingdom. And we end with the remark that these facts of persistent activity, called out by an initial excitement, lend support to the idea that living forces hold a close connection with the molecular structure of bodies, and may even be the determinate expression of that structure. We cannot conceive manifold energy in a mathematical and irreducible atom; but in a molecule, made up of a certain number of atoms, we can fancy dynamic figures of a very complex order.

We have thus far regarded only the action of white light, the effect of the totality of rays sent us by the sun; but this light is not simple. It is composed of a great number of radiations, of distinct colors and properties. When white light is decomposed by the prism, we obtain seven groups of visible rays, of unequal refractive power, violet, indigo, blue, green, yellow, orange, and red. The spectrum or ribbon of colors thus obtained widens and spreads out by invisible radiations. Beyond the red, there exist radiations of dark heat, or calorific-rays, and, outside of the violet, radiations which are called chemical or ultra-violet rays. The first affect the thermometer, the last occasion energetic reactions in chemical compounds. What is their influence upon vegetation? Does solar light act by its colored rays, its heat-rays, or its chemical rays?

The question has been subjected to many important experiments, and is, perhaps, not yet determined. Daubeny, in 1836, was the first

to watch the respiration of plants in colored glasses, and he found that the volume of oxygen released is always less in the colored rays than in white light. The orange rays appeared to him most energetic; the blue rays coming next. A few years later, Gardner, in Virginia, exposed young, feeble plants, from two to three inches long, to the different rays of the spectrum, and observed that they regained a green color with a maximum rapidity under the action of the yellow rays and those nearest them. In one of his experiments, green color was produced, under the yellow rays, in three hours and a half, under orange rays in four hours and a half, and under the blue, only after eighteen hours. Thus it is seen that the highest force of solar action corresponds neither with the maximum of heat, which is placed at the extremity of the red, nor with the maximum of chemical intensity, situated in the violet, at the other edge of the spectrum. Those radiations which are most active, from a chemical point of view, are the ones which have the least influence over the phenomena of vegetable life.

Mr. Draper, at present a professor in the New York University, and the author of a very remarkable history of the intellectual development of Europe, undertook new and more accurate experiments about the same time. He placed blades of grass in tubes filled with water which was charged with carbonic gas, and exposed these tubes, near each other, to the different rays of the solar spectrum. Then measuring the quantity of oxygen gas disengaged in each one of these little vessels, he proved that the largest production of gas occurred in the tubes exposed to the yellow and green light; the next, in the orange and red rays. In 1848, Cloëz and Gratiolet discovered the singular fact that the action of light on vegetation is more powerful when it passes through roughened glass than when transmitted through transparent glass. Julius Sachs, more lately, conceived the idea of measuring the degree of intensity of light-action, upon aquatic plants, by counting the number of gas-bubbles released by a cutting of a branch exposed to the sun in water charged with carbonic acid. He thus observed that the bubbles thrown off under the influence of orange light are very little less numerous than under white light, while the branch put under blue light throws out about twenty times less. These experiments are decisive. Neither the chemical nor the calorific rays of the solar beam act on plants. The luminous rays only, and chiefly the yellow and the orange, have that property. To these clearly-settled results, Cailletet added a new fact, that green light acts on vegetation in the same way as darkness. He assigns this reason for the feebleness of vegetation bathed in green light under the shade of large trees. It is true, this discovery of Cailletet has been warmly questioned recently, but it has found defenders too, Bert among others, and we shall find soon that it harmonizes with the whole system of the actions of light in the two kingdoms of life.

A year ago, science had gone thus far, when a very distinguished

botanist, Prillieux, published the result of a course of experiments made with an entirely different purpose, and taking up the study of the action of light from a new point of view. Resting on the twofold consideration that the distinctly-colored rays are not equally luminous, and that those of the greatest illuminating power are also those which act with most energy on plants, Prillieux undertook to examine what influence will be exercised on plants by rays different in color, but known to be equal in intensity, and whether this influence differs in the case of different colors, or is the same, provided they do not vary in illuminating power. The long and conscientious researches of this experimenter led him to the conclusion, that rays of different colors act with equal force on the green parts of plants, and produce an equal release of gas, when they have the like luminous intensity. He holds that all luminous rays effect the reduction of carbonic acid by vegetables in proportion to their illuminating power, whatever their refrangibility may be. If the yellow and orange rays are more active in this respect, it is because their luminous glare is much greater than that of the extreme rays.

The luminous rays also promote the production of green tissue, the green matter of all vegetables. Gardeners blanch certain plants by raising them in the dark. They thus obtain plants of a pale yellow, spindling, without strength or crispness. They are attacked by a true chlorosis, and waste away, as if sprung from barren sand. The sun also aids the transpiration of plants, and the constant renewal of healthy moisture in their tissues. On failure of the evaporation of moisture, the plant tends to grow dropsical, and its leaves fall, from weakness of the stem.

This love of plants for light, which is one of the most imperious needs of their existence, displays itself also in other interesting phenomena, which show that solar rays are, in very truth, the fertilizer that produces color. The corolla of vegetable species growing at great heights on mountains has livelier colors than that of species that spring in low spots. The sun's rays, in fact, pass more easily through the clear atmosphere that bathes high summits. The hue of certain flowers even varies according to the altitude. Thus the corolla of the *Anthyllis vulneraria* shades down from white to pale red and vivid purple. In general, the vegetation of open, well-lighted places is richer in color and development than that of regions not accessible to the sun. Some flowers originally white afterward deepen in color by the direct action of light. Thus *Cheiranthus cameleo* has a flower at first whitish, afterward yellow, and, at last, a violet-red. The *Hibiscus mutabilis* bears a flower which opens at morning with a white hue, and grows red during the day. The flower-buds of the *Agapanthus umbellatus* are white when they begin to unclose, and afterward take on a blue tint. If, at the moment of leaving its spathe, the flower is wrapped in black paper, intercepting the light, it remains white, but regains its

color in the sun. The tints of fruits in the same way develop under the healthy action of daylight, and the rule extends to those principles of every nature which give taste and odor to the different parts of the the plant.

Flowers, fruits, and leaves, then, are elaborated by the help of luminous vibrations. Their tissue holds the sun's rays. Those charming colors, those fragrant perfumes, and delicious flavors, all the innocent pleasures the vegetable kingdom yields us, owe their creation to light. The subtle working of these wonderful operations eludes us, as does that which guides the fleeting diffusion and thousand-fold refractions displayed by the imposing spectacle of the dawn; but is it nothing to gain a glimpse of those primal laws, and to possess even a twilight ray upon these magnificent phenomena?

II.

Light exerts a mechanical influence on vegetables. The sleep of flowers, the bending of their stems, the nutation of heliotropic plants, the inter-cellular movements of chlorophyll, offer proofs of an extremely delicate sensitiveness of certain plants in this respect. Pliny mentions the plant called the sunflower, which always looks toward the sun, and steadily follows its motion. He notices, too, that the lupin always follows the sun in its daily movement, and points out the hour for laborers. Tessier, at the end of the last century, took up the study of these phenomena, and inferred in a general way that the stems of plants always turn toward the light, and bend over, if necessary, to receive it. He noted, too, that leaves tend to turn toward the side whence daylight comes. Payer made more exact experiments. He tried them with young stems of common garden cresses grown on damp cotton in the dark. These stems have the property of curving and turning quickly when placed in a room lighted only from one side or in a box receiving light on one wall only. The upper part of the stem curves first, the lower part remaining straight. By a second movement the top erects and the bottom bends over, so that the plant, though leaning, becomes almost rectilinear again. When put in a room receiving light from two windows, the following results are noticed: If the openings are on the same side admitting light equally, the stem bends in the direction of the middle of the angle formed by these two beams; if one of the two windows admits more light than the other, the stem leans toward it; if the windows are opposite each other, the stem stands erect, when light comes equally from both sides, and, if it does not, turns toward the stronger rays. Payer discovered, moreover, that the part of the irradiating light most active in its effects corresponds in this case to the violet and the blue. The red, orange, yellow, and green rays, do not seem to produce any movement in plants. Gardner carried the investigation still further. He sowed turnips, and let them develop in the dark to two or three inches in

length. Then he threw the solar spectrum by a prism on this little field. The plants inclined toward a common axis. Those exposed to the red, orange, yellow, and green rays, leaned toward the deep blue, while the part lighted by violet bent in the opposite direction. Thus the crop took the appearance of a wheat-field bowing under two contrary winds. The turnips placed in the violet-blue region looked toward the prism. Gardner thus determined, as Payer had done, that the most refrangible rays are those which effect the bending of the young stems. He proved also that the plants grow erect again in the dark.

These experiments, repeated and varied in many ways by Dutrochet and Guillemin, uniformly gave like results, but the phenomenon itself still remains almost unexplained. This remark also applies to the very singular facts of the twisting of running plants. The stems of these plants, in twining about their supports, usually curl from the left to the right. Others follow the contrary course, and some twist indifferently in either way. Charles Darwin inferred, from his investigation, that light has an effect on this phenomenon. If twining plants are put in a room near a window, the tip of their stalk takes longer to complete the half circuit during which it turns toward the darker part of the room than that which is described nearer the window. Thus one of them, having gone through a whole turn in five hours and twenty minutes, the half circle toward the window employed a little less than an hour, while the other was not traversed in less than four hours and a half. Duchartre placed some China yams in full vegetation in a garden, and others in a completely dark cellar. The stems of the plants uniformly lost in the dark the power of twisting around their supporting sticks. Those exposed to the sun presented one portion twisting, but when put in the cellar they shot out straight stems. Yet some twining plants are known that seem to be independent of light in twisting.

The sleep of plants, in connection with light particularly, is still less understood. The flowers and leaves of certain vegetables droop and wither at fixed hours. The corolla closes, and after quiet inaction the plant again expands. In others, the corolla drops and dies without closing. In others still, as the convolvulus, the closing of the flower occurs only once, and its sleep marks its death. Linnæus noted the hours of opening and shutting in certain plants, and thus arranged what has been called Flora's clock; but the relations of these closings with the intensity of light have not yet been scientifically determined.

The green coloring of vegetable leaves and stems is due to a special substance called chlorophyll, which forms microscopic granulations contained in the cells which make up these stems and leaves. These grains are more or less numerous in every cell, and it is their number as well as intensity of color that determines the tint of the plant's tissues. Sometimes they are closely pressed together, covering

the whole inner surface of the cell; sometimes the quantity is smaller, and they are separate. Now, it has lately been discovered that in the latter case, under the influence of light, the green corpuscles we speak of undergo very singular changes of position. Some twelve years ago, Boehm noticed for the first time that in certain unctuous plants the grains of chlorophyll gather at one point of the wall of the cells under the action of the sun. He remarked that the phenomenon does not take place in the dark, nor in the red rays. The flat sheet made up of a single layer of cells, without epidermis, which composes the leaves of mosses, seemed to Famintzin the most suitable for this delicate kind of observations. He followed the movements, that take place in these sheets, by microscopic study. During the day the green coloring-grains are scattered about the upper and lower parts of the leaf-cells. At night, on the contrary, they accumulate toward the lateral walls. The blue rays affect them like white light; the yellow and the red ones keep the chlorophyll in the position it takes at night. The order of activity in the rays seems, then, to differ in this case from that in the phenomena of respiration. The researches of Borodine and Prillieux proved that these movements of coloring-corpuscles within the cells occur in almost all cryptogamous plants, and in a certain number of phanerogamous ones. The lately-published experiments of Roze show that in mosses the grains of chlorophyll are connected by very slender threads of plasma, and may suggest the idea that these threads are the cause of the changes of position just described. Perhaps there is some real relation between them; but it must not be forgotten that these movements of the plasmatic matter inside the cell take place by day and night, and that light has no marked effect on them. The green particles, on the contrary, creep over the walls of the cell, and move toward the lightest part as zoospores and some infusoria do.

Biot relates that in 1807, while at Formentera, employed in the work of extending the meridional arc, he devoted his leisure hours to the analysis of the gas contained in the swimming-bladder of fishes living at different depths in the sea. The oxygen required for these analyses was furnished him by the leaves of the *cactus opuntia*, which he exposed in water to sunlight, under hand-glasses, ingeniously applying the discovery of Ingenhousz and Senebier. It occurred to him one day to expose these leaves, in a dark place, to the illumination thrown by lamps placed in the focus of three large reflectors, used for night-signals in the great triangulation. He threw the light from three of these reflectors on the cactus-leaves. The eye, placed in this concentration of light, must have been struck blind, Biot says. The experiment, kept up for an hour, did not cause the release of a single gas-bubble. The glass was then taken into the diffused light outside the hut. The sun was not shining, but the evolution of gas took place at once with great rapidity. Biot is a little surprised at the result and

concludes that artificial light is impotent to do what solar light can. The labors of Prillieux and other contemporary botanists have proved that all light acts on the respiration of plants, provided only it is not too powerful. In Biot's case artificial light had no effect, because it it was far too intense.

III.

Lavoisier somewhere says: "Organization, voluntary movement, life, exist only at the surface of the earth, in places exposed to light. One might say that the fable of Prometheus's torch was the expression of a philosophic truth that the ancients had not overlooked. Without light, Nature was without life; she was inanimate and dead. A benevolent God, bringing light, diffused over the earth's surface organization, feeling, and thought." These words are essentially true. All organic activity was very clearly at first borrowed from the sun, and if the earth has since stored away and made its own a quantity of energy, that sometimes suffices to produce of itself that which originally proceeded from solar stimulus, it must not be forgotten that those living forces, of startling and complex aspects, sometimes our pitiless enemies, often our docile servants, have descended, and are still descending upon our planet, from the inexhaustible sun. The study of animal life shows us by striking instances the physiological efficacy of light, and the immaterial chain, it may be called, which links existences with the fiery and abounding heart of the known universe.

In plants, as we have seen, respiration at night is the reverse of that by day. There are infusoria which behave, under the influence of light, exactly like the green portions of plants. These microscopic animalcula are developed in fine weather in stagnant water, and in breathing produce oxygen at the expense of the carbonic acid contained in the liquid. Morren saw that the oxygenation of the water occasioned by these little beings varied very perceptibly in the course of twenty-four hours. It is at the minimum at sunrise, and reaches its maximum toward four in the afternoon. If the sky is overcast, or the animalcula disappear, the phenomenon is suspended. This is only an exception. Animals breathe at night in the same way as in the daytime, only less energetically. Day and night they burn carbon within their tissues, and form carbonic acid, only the activity of the phenomenon is much greater in light than in darkness.

Light quickens vital movements in animals, especially the act of nutrition, and darkness checks them. This fact, long known and applied in practical agriculture, is expressly noted by Columella. He recommends the process of fattening fowls by rearing them in small dark cages. The laborer, to fatten his cattle, shuts them up in stables lighted by small low windows. In the half-light of these prisons the work of disassimilation goes on slowly, and the nutritive substances, instead of being consumed in the circulating fluid, more readily accu-

mulate in the organs. In the same way, for the sake of developing enormous fat livers in geese, they are put into dark cellars, kept entirely quiet, and crammed with meal.

Animals waste away as plants do. The absence of light sometimes makes them lose vigor, sometimes entirely changes them, and modifies their organization in the way least favorable to the full exercise of their vital powers. Those that live in caverns are like plants growing in cellars. In certain underground lakes of Lower Carniola we find very singular reptiles resembling salamanders, called proteans. They are nearly white, and have only the rudiments of eyes. If exposed to light they seem to suffer, and their skin takes a color. It is very likely that these beings have not always lived in the darkness to which they are now confined, and that the prolonged absence of light has destroyed the color of their skins and their visual organs. Beings thus deprived of day are exposed to all the weaknesses and ill effects of chlorosis and impoverishment of the blood. They grow puffy, like the colorless mushroom, unconscious of the healthy contact of luminous radiance.

William Edwards, to whom science owes so many researches into the action of natural agents, studied, about 1820, the influence exercised by light on the development of animals. He placed frogs'-eggs in two vessels filled with water, one of which was transparent, and the other made impermeable to light, by a covering of black paper. The eggs exposed to light developed regularly; those in the dark vessel yielded nothing but rudiments of embryos. Then he put tadpoles in large vessels, some transparent, others shielded from the light. The tadpoles that were shone upon, soon underwent the change into the adult form, while the others either continued in the tadpole condition, or passed into the state of perfect frogs with great difficulty. Thirty years later, Moleschott performed some hundreds of experiments in examining how light modifies the quantity of carbonic acid thrown off in respiration. Operating on frogs, he found that the volume of gas exhaled by daylight exceeds by one-fourth the volume thrown off in darkness. He established, in a general way, that the production of carbonic acid increases in proportion to the intensity of light. Thus, with an intensity represented by 3.27, he obtained 1 of carbonic acid, and, with an intensity of 7.38, he obtained 1.18. The same physiologist thinks that in batrachians the intensity of light is communicated partly by the skin, partly by the eyes.

Jules Béclard made more thorough researches. Common flies'-eggs, taken from the same group, and placed at the same time under differently-colored glasses, all produce worms. But if the worms, hatched under the different glasses, are compared at the end of four or five days, perceptible differences may be seen among them. Those most developed correspond with the violet and blue ray; those hatched under the green ray are far less advanced; while the red, yellow, and

white rays exert an intermediate action. A long series of experiments on birds satisfied Béclard that the quantity of carbonic acid thrown out in breathing, during a given time, is not sensibly modified by the different colors of the glasses the animals are placed under. It is the same with small mammifers, such as mice; but it is to be observed in this case that the skin is covered either with hair or feathers, and the light does not strike the surface. The same physiologist examined also the influence of the different-colored rays of the spectrum on frogs. Under the green ray, the same weight of frogs produces in the same period of time a greater quantity of carbonic acid than under the red ray. The difference may be a half greater; it is usually a third or a fourth greater; but if the skin is afterward taken off the frogs, and they are replaced under the same conditions, the result alters. The amount of carbonic acid thrown out by the flayed frogs is greater in red than in green light. A few experiments tried by Béclard on the exhalation of the vapor of water by the skin show that in the dark, temperature and weight being alike, frogs lose by evaporation a half or a third less moisture than under white light. In the violet ray the quantity of moisture lost by the animal is perceptibly the same as in white light.

Light acts directly on the iris of almost all animals, and thus produces contraction of the pupil, while heat produces the reverse phenomena. This stimulus is observed in eyes that have been separated for some time from the body, as Brown-Séquard has shown.

Bert lately took up some very curious experiments on the preference of animals for differently-colored rays. He took some of those almost microscopic crustacea, common enough in our fresh waters, the daphne-fleas, remarkable for their eager way of hurrying toward light. A number of these insects were put into a glass vessel, well darkened, and a spectrum of the ray then thrown into it. The daphnes were dispersed about the dark vessel. As soon as the spectrum-colors appeared, they began to move, and gathered in the course of the luminous track, but, when a screen was interposed, they scattered again. At first all the colors of the spectrum attracted them, but it was soon noticed that they hurried much more toward the yellow and green, and even moved away a little if these rays were quickly replaced by the violet. In the yellow, green, and orange parts of the spectrum there was a thronging and remarkable attraction. A pretty large number of these little beings were remarked in the red, too, a certain number in the blue, and some, fewer in proportion to the distance, in the most refrangible portions of the violet and ultra-violet. For these insects, as for ourselves, the most luminous part of the spectrum was also the most agreeable. They behaved in it as a man would do who, if he wished to read in a spectrum thrown about him, would approach the yellow and avoid the violet. This proves, in the first place, that these insects see all the luminous rays that we see ourselves. Do they

perceive the chlorific and chemic rays, that is to say, the ultra-red and ultra-violet ones, which do not affect our retina? Bert's experiments enable us to answer that they do not. That physiologist is even led to assert that, with regard to light and the different rays, all animals experience the same impressions that man does.

Let us now look at the influence of light upon the color of the skin in animals, noticing first the being which presents the strangest peculiarities in this respect, the chameleon. This animal, indeed, experiences very frequent modifications of color in the course of the same day. From Aristotle, who attributed these changes to a swelling of the skin, and Theophrastus, who assigned fear as their cause, to Wallisniéri, who supposes them to result from the movement of humors toward the surface of the animal's body, the most different opinions have been expressed on this subject. Milne-Edwards, thirty years ago, explained them by the successive inequalities in the proportions of the two substances, one yellowish and the other violet, which color the skin of the reptile, inequalities due to the changes in volume of the very flattened cells that contain these substances. Bruck, renewing these researches, proves that the chameleon's colors follow from the manifold dispersion of solar light in the colored cells, that is to say, from the production of the same phenomenon remarked in soap-bubbles and all very thin plates. Its colors, then, come from the play of sunlight among the yellow and violet substances distributed very curiously under its wrinkled skin. It passes from orange to yellow, from green to blue, through a series of wavering and rainbow-like shades, determined by the state of the light's radiation. Darkness blanches it, twilight gives it the most delicate marbled tints, the sun turns it dark. A part of the skin bruised or rubbed remains black, without growing white in the dark. Bruck satisfied himself, moreover, that temperature does not affect these phenomena.

All animals having fur or feathers are darker and more highly colored on the back than on the belly, and their colors are more intense in summer than in winter. Night-butterflies never have the vivid tints of those that fly by day, and among the latter those of spring have clearer, brighter shades than the autumn ones. The gold-and-azure dust that adorns them harmonizes with the tones of colors in surrounding Nature. Night-birds, in the same way, have dark plumage, and the downiness of their coverings contrasts with the stiffness of those that fly by day. Shells secluded under rocks wear pale shades, compared with those that drink in the light. We have spoken above of cave-animals. What a distinction between those of cold regions and those of equatorial countries! The coloring of birds, mammals, and reptiles, peopling the vast forests or dwelling on the banks of the great rivers in the torrid zone, is dazzling in its splendor. At the north we find gray tints, dead and of little variety, usually close upon white, by reason of the almost constant reflection from snow.

Not only the color of organized beings, but their shape too, is linked with the action of light, or rather of climate. The flora of the globe gain increasing perfection as we go from the poles toward the equator. The nearer these beings approach the highest degree of heat and light, the more lavishly are richness, splendor, and beauty, bestowed on them. The energy and glory of life, perfect forms as well as brilliant arraying, are the distinguishing mark of the various and manifold races in tropical regions, giving this privileged world its characteristic aspect. A pure emanation from the sun, Nature here lives wild and splendid, gazing unshrinkingly, like the Alpine eagle, on the eternal and sublime source which inundates it with heat and glow. Look, now, at the regions of the pole! A few dwarfish shrubs, a few stunted and herbaceous plants, compose all its flora. Its animals have a pale covering and downy feathers; its insects, sombre tints. All around them are the utmost limits of life—ice invades every thing, the sea alone still breeds a few acalephs, some zoophytes, and other low rudimentary organizations. The sun comes aslant and seldom. At the equator he darts his fires, and gives himself without stint to the happy Eden of his predilection.

IV.

It remains to note the relations of light to that being most sensitive to its influence, and best able to express its effects, man himself. The new-born child seeks the day by instinct, and turns to the side whence light comes, and, if this spontaneous movement of the infant's eyes is thwarted, strabismus may be the consequence.

Of all our organs the eye is the one that light especially affects. Through the eyes come all direct notions of the outer world, and all impressions of an æsthetic kind. Now, the excitability of the retina shows variations of every kind. Prisoners confined in dark cells have been known to acquire the power of seeing distinctly in them, while their eyes also become sensitive to the slightest changes in the intensity of light. In 1766 Lavoisier, in studying certain questions upon the lighting of Paris, which had been given for competition by the Academy of Sciences, found after several attempts that his sight wanted the necessary sensitiveness for observing the relative intensities of the different flames he wished to compare. He had a room hung with black, and shut himself up in it for six weeks in utter darkness. At the end of that time his sensitiveness of sight was such that he could distinguish the faintest differences. It is very dangerous, too, to pass suddenly from a dark place into a strong flood of light. The tyrant Dionysius had a building made with bright, whitewashed walls, and would order wretches, after long seclusion from light, to be suddenly brought into it. The contrast struck them blind. Xenophon relates that many Greek soldiers lost their sight from reflections off the snow in crossing the mountains of Armenia. All travellers who have visited

the polar regions have often seen like results produced by the glare of the snow. When the impression of light on the eye is sudden and overpowering, the retina suffers most. If it is less powerful, but longer continued, the humors of the eye are affected. The phenomenon called sunstroke results from the action of light, and not, as is often supposed, from excessively high temperature. It sometimes occurs in the moderately warm season of spring; or a very intense artificial light, and particularly the electric light, may occasion it. The violet and ultra violet parts of the sunbeam seem to be the cause of this action, for screens of uranium glass, that absorb these portions, protect the eyes of experimenters occupied in studying the electric light. This disorder is a true inflammation.

The action of light on the human skin is manifest. It browns and tans the teguments, by calling out the production of the coloring-matters they contain. The parts of the body usually bare, as the skin of the face and hands, are darker than others. In the same region, country-people are more tanned than town residents. In latitudes not far apart, the inhabitants of the same country vary in complexion in a measure perceptibly related to the intensity of solar light. In Europe three varieties of color in the skin are distinctly marked: olive-brown, with black hair, beard, and eyes; chestnut, with tawny beard and bluish eyes; blond, with fair, light beard and sky-blue eyes. White skins show more readily alterations occasioned by light and heat; but, though less striking, facts of variation in color are observable in others. The Scytho-Arabic race has but half its representatives in Europe and Central Asia, while the remainder passes down to the Indian Ocean, continuing to show the gradual rising heat of climate by deepening brown complexions. The Himalayan Hindoos are almost white; those of the Deccan, of Coromandel, Malabar, and Ceylon, are darker than some negro tribes. The Arabs, olive and almost fair in Armenia and Syria, are deep brown in Yemen and Muscat. The Egyptians, as we go from the mouths of the Nile up-stream toward its source, present an ascending chromatic scale, from white to black, and the same is true of the Tuariks on the southern side of Mount Atlas, who are only light-olive, while their brethren in the interior of Africa are black. The ancient monuments of Egypt show us a fact equally significant. The men are always depicted of a reddish brown; they lived in the open air, while the women, kept shut up, have a pale-yellow complexion. Barrow asserts that the Mantchoo Tartars have grown whiter during their abode in China. Rémusat, Pallas, and Gutzlaff, speak of the Chinese women as remarkable for a European fairness. The Jewesses of Cairo or Syria, always hidden under veils or in their houses, have a pallid, dead color. In the yellow races of the Sumatra Sound and the Maldives, the women, always covered up, are pale like wax. We know, too, that the Esquimaux bleach during their long winter. These phenomena, no doubt, are the results of several influ-

ences acting at once, and light does not play the sole part in them. Heat and other conditions of the medium probably have a share in these operations of color. Still, the peculiar and powerful effect of luminous radiation as a part of them is beyond dispute.

The whole system of organic functions shares in the benefits of light. Darkness seems to favor the preponderance of the lymphatic system, a susceptibility to catarrh in the mucous membranes, flaccidity of the soft parts, swellings and distortions of the bony system, etc. Miners and workmen employed in ill-lighted shops are exposed to all these causes of physiological suffering. We may notice, with regard to this, that certain rays of the solar beam affect animals like darkness; among others, the orange light, which, according to Bert, hurts the development of batrachians. Now, if this light is injurious to animals, it is not so to plants, as we have seen. In exchange, green light, which is hurtful to vegetables, is extremely favorable to animals. There is a kind of opposition and balance, then, as respects luminous affinities, between the two great kingdoms of life. White light, as Dubrianfant says, seems to split up under the influence of living beings into two complementary groups, a green group and an orange group, which exhibit in Nature antagonistic properties. It is quite certain that green light is a very lively and healthful stimulant for our functions, and that, for that reason, spring is the favored and enchanted season.

The correspondence between perfection of forms and heightening of luminous intensity proves true in the human race as in others. Æsthetics, agreeing with ethnography, demonstrate that light tends to develop the different parts of the body in true and harmonious proportion. Humboldt, that nice observer, says, speaking of the Chaymas: "The men and women have very muscular bodies, but plump, with rounded forms. It is needless to add that I have never seen a single one with any natural deformity. I will say the same of so many thousands of Caribs, Muycas, Mexican and Peruvian Indians, whom we have observed during five years. These bodily deformities and misgrowths are extremely rare in certain races of men, especially among people who have a deep-colored skin." No doubt there is great difficulty in conceiving how light can model—can exert a plastic power. Yet, reflecting on its tonic effect on the outer tegument, and its general influence over the functions, we may assign it the part of distributing the vital movement orderly and harmoniously throughout the whole of the organs. Men who live naked are in a perpetual bath of light. None of the parts of their bodies are withdrawn from the vivifying action of solar radiation. Thence follows an equilibrium which secures regularity in function and development.

It is commonly said that an ordained causality rules the operations of matter, and that free spontaneity is the privilege of those of spirit. It might well be said on this subject that, in many cases, the causes

acting in matter elude us, and, not less often, the causes which act in spirit overpower us; but it is not our task to elucidate that terrible antithesis of law, when the genius of Kant failed in it. We would only ask it to be observed how great an influence light has on the system of the intellectual functions. The soul finds in it the least deceiving of the consolations it seeks for the eternal sadness of our destiny—the bitter melancholy of life. Thought, fettered and dumb in a dark place, springs into freedom and spirit at evening, in a room brilliant with light. We cannot shun the sad moods caused by gloomy and rainy weather, nor resist the impulse of joy given by the spectacle of a brilliant day. Here we must confess our slavery—yet a slavery to be welcomed, that yields only delights. And why should we not join in the chorus of all animate and inanimate things, which, at the touch of light, quiver, and thrill, and betray in a thousand languages the magical, rapturous stimulus of that contact? By instinct, and spontaneously, we seek it everywhere, always happiest when it is found. In some sort, it suffices us. And what a part it plays, what a charm it gives, in works of poetry and art!

This is not the place to unfold that attractive and hardly-opened chapter of æsthetics—to demonstrate the relation between the atmosphere and art, by interrogating the climates of the globe and the great masters of all ages, not following a system of empirical analogies and far-fetched suggestions, but led by strict physiology and rigid optic laws. A charming picture would unfold in tracing the countless and changeful aspects of the sky, and all the caprices of light and air in their influence over the moral and physical nature of painters, poets, and musicians. The ever-varying face of the sun, the fires of dawn and sunset, the opalescent play of air, the shimmer of twilight, the blue, green, shifting hues and iridescent gleams of sea or mountain—all these things find a destined answer in the inmost and unconscious ongrowings of life, as in the soul of one who looks understandingly at Nature's works. In it they reveal and transform themselves by subtlest thrills—tender and creative. He who shall detect these—shall link, range, and embrace them in their wonderfully complex unity—will render a great service to science and to art. He will not make the artist an automaton, nor prove man the copy of a plant, drawing all its virtues from the soil it springs in, but he will lay his hand upon the mechanism, as yet scarcely guessed, moving a whole system of mighty combinations of energy.—*Revue des Deux Mondes.*

A NEW PHASE OF GERMAN THOUGHT.

THE PHILOSOPHY OF THE UNCONSCIOUS.

FROM THE FRENCH OF LÉON DUMONT.

II.

HARTMANN adopts the following words as the title of his principal work: "Speculative results according to the inductive method of the natural sciences." If we were to trust to these words, we might suppose that the author's system takes an essentially scientific form, and relies exclusively on the observation and analysis of facts. But the reading of a very few chapters soon leaves quite an opposite impression. Although Hartmann gives proof of abundant acquisitions in physics and physiology, he puts himself completely at odds with the naturalist school, and, soaring away at once, launches into the metaphysical regions haunted by Schelling and Schlegel. He begins, it is true, by setting forth quite a number of facts belonging to the domain of the natural sciences, but he follows with the immediate declaration that such facts can only be explained by a cause of the supernatural order. Now, to take any fact whatever, and endeavor to show that it is not a result of physical conditions, but has its cause in a spiritual principle, intelligent and distinct from its reality, may not, we suppose, be necessarily false, but we certainly cannot recognize, in such a procedure, "the inductive method of the natural sciences."

The principle of final causes is the starting-point of the system. In vain Bacon, Descartes, Spinoza, Kant, have successively combated it; in vain Darwin has given it its death-blow, by the proof that every thing heretofore conceived as a final cause in the organic world might be hypothetically, if not by demonstration, explained as a result; in Hartmann's teaching, the idea of finality once more takes a place perhaps as high as in that of ancient philosophic systems. He says, the causes of a fact are necessarily either material or spiritual—there is no middle way; therefore, when material circumstances fail to explain a fact sufficiently, we must resort to the admission of a spiritual cause. Now, when the mind acts, there is always a will joined with an idea, a force tending to the realization of an end conceived; in a word, there is always a final cause. Therefore, to prove the existence of a providential principle, it is enough to show that certain facts cannot possibly be reduced to material conditions.

This doctrine may be thus stated: Whatever we have not yet succeeded in grasping by observation is of a spiritual nature, or, whatever in the production of a fact has hitherto eluded our experimental research, must be *a priori* a principle like the human intellect. Is not

this simply going back to that old anthropomorphism of primitive philosophy, according to which imagination was childishly led to conceive, behind any phenomenon inexplicable by ignorance, a will, a force, like that we are conscious of within ourselves? This illusion has gradually lost ground, for two reasons: first, because the sphere of the unknown has gone on diminishing, as the conquests of science have continually revealed new natural explanations of phenomena; and, next, because we are brought more and more nearly to the conviction that the human intellect, the will, instead of being principles of a transcendent order, are themselves only results of material conditions. We can maintain such a doctrine, and yet repel the charge of materialism; for matter, in our view, is far from being a principle; we regard it only as a fact which is capable of being analyzed in its turn, and of being reduced to yet simpler elements, to forces, which are not in themselves substances, but merely phenomena.

One of the most characteristic traits of the spiritualist temperament is this—that in the explanation of facts it always prefers metaphysical hypotheses to purely physical ones; that it clings to the former as long as it is possible to do so without too violent a contradiction of irresistible truths; that it never yields to such truths, except in the last extremity, nor ever until they have been established by proofs beyond refutation. This is the mental bent of which we find the signs in Hartmann's theories. There are, in fact, a certain number of phenomena, of which the physical and physiological sciences have succeeded in giving probable explanations, without going beyond their own domain; but these explanations are as yet in the state of conjectures, or at least have not been verified by experiences so decisive as to compel the most hardened metaphysicians to accept them. Instead of these solutions, Hartmann, in conformity so far with spiritualistic traditions, prefers to hold to the hypothesis of an intelligent principle, yet an unconscious one. Let us examine the principal facts of this kind in order.

Hartmann contends that any voluntary movement must be impossible, without an idea of the extremity of the nerve that serves to produce it; and, as this idea does not exist in consciousness, it must exist, as he holds, in an unconscious intelligence, of which my conscious intelligence is doubtless only a mode, a manifestation. I will to move my arm, and it moves. How can that effect be produced, Hartmann asks, without the knowledge of the intermediate organs, which must be set at work to effect the intended act? How otherwise can we explain the action of the will on some one particular muscle, rather than on some other one? We may well be astonished to find such a theory held by a philosopher who admits that acts of the conscious will are phenomena of the brain. Is it not a more natural and probable sequence to suppose an organic adaptation between the cerebral phenomenon and the modification of the motor nerve? But, it

is objected, What has the power to establish such adaptation, except an intelligent being? We shall reply, that all those phenomena which are usually simultaneous in the organism have the power of suggesting each other, that is to say, of acting reciprocally as causes. They do in the end compose a circle, which vibrates throughout, whichever one of its links it may be that receives the impulse. Every gesture, every external movement of the body, is naturally followed by its perception, and consequently by its idea; by dint of being contemporaneous with the organic facts which determine the production of motion, the idea forms in connection with them habits of adaptation, the result of which is to give it the property of exciting them. Thus, the movement was at first involuntary, and theretofore it was the movement which stirred its idea in the intellect, through the intermediate means of perception; afterward the movement became voluntary, and it may be was caused, in its turn, by the cerebral phenomenon of its idea, which had had time to contract habits of coexistence, and of suggestion with the intermediate modifications of the nerves and the muscles. Such habits may even show themselves, so far as they are hereditarily reproduced and continued, as if they were innate with the individual.

It is the same with regard to those reflex movements which Hartmann also refers to an unconscious will and intelligence. He defines a reflex movement as "that which takes place when the excitement of a nerve of motion is transmitted to a nervous centre, which transmits it on to another nerve of motion, that produces in the last place a muscular contraction." This definition is evidently too broad, and would equally embrace all those movements that result from cerebral action; for the brain is also a nervous centre, which only transforms movements that come from outside of it, so as to transmit them to motor nerves. Physiologists usually confine the description of "reflex" to those movements as to which the series of facts intermediate between the external excitement received and the final act does not pass through the me, or the thinking brain.[1] Now, among these movements, certain distinctions must be established. In a great number of them the most prejudiced mind could not discover any sign of finality, and therefore as to those there cannot even be any question of applying an hypothesis of an intelligence, whether conscious or unconscious; when, for instance, some one tickles me, and I laugh, I cannot recognize any thing between these two facts of laughing and of tickling, beyond an accidental and mechanical coincidence. Other reflex movements are very easily explained upon the hypothesis of natural selection; such, for instance, is the action of the spinal marrow on the

[1] In the strictest meaning of the term, a reflex phenomenon is a movement called forth in one part of the body by an excitement proceeding from that part, and acting intermediately through a new centre, other than the brain, properly called, and consequently without the intervention of the will.—(VULPIAN, *Lectures on the General and Comparative Physiology of the Nervous System.*)

muscles of the blood-vessels; such are the movements of the respiratory organs, etc. Again, there are a great number of cases in which the adaptation between the excitement and the act must have been originally regulated by conscious intelligence; but, the habit once acquired, the concurrence of intelligence has become useless. The player on a musical instrument needs at first to combine, by an act of his will, the movements of the fingers with the visual perception of the notes; but, after a sort of organic coexistence between these facts is established by repetition and practice, the one may become directly the cause of the other, without the concurrence of the power that regulated their adaptation; the movements of the hand then follow the impressions on the sight mechanically, while the intellect may be occupied with something quite different. Thus a machine, once constructed and regulated, has no need of the intelligent workman, who adjusted its cogs and wheels, to keep it going. If we pinch a frog after its brain is removed, it makes motions as though to repel the hand that hurts it; it is a reflex action resulting from habits contracted under the cerebral influence, and strongly enough established to survive the removal of the intellectual organs. After this we do not deny that a certain degree of intelligence may exist in other nervous centres besides the brain; we grant that they may have a peculiar consciousness of their modifications and their movements. But we go no further, and we refuse to follow Hartmann, as soon as his hypotheses needlessly take on a metaphysical or supernatural character.

Still less shall we follow him when, throwing himself into theories which remind us of those of Stahl, he insists that the organization of living bodies can be formed no otherwise than by the action of an intelligent but unconscious principle; that, in diseases, a regulating intelligence, a *vis medicatrix naturæ*, presides over the restoration of the functions to their normal state; that the reproduction of organs observed in some animals is caused by the unconscious idea of the usefulness of such organs, for the preservation of the individual; that in every part of the living being there resides an unconscious idea of the type of the species, which directs the reproduction of the organ removed, the reparation of tissues, etc. These facts, all having relation to the study of forms, types, or species, are exactly those which Darwin's theory best succeeds, as we think, in explaining. Hartmann, however, does not altogether reject the ideas of the great English naturalist; but he limits their application considerably, and interprets them in a manner quite contrary to their author's. He admits natural selection, indeed, in the struggle for existence; but this selection is not, in his view, a primordial fact, resulting from the force of things; he calls it simply one of the means that unconscious intelligence would employ in arriving at its ends. Besides, selection would be insufficient still, according to Hartmann, to account for the organic forms of the species, for what he calls the morphological facts, and ought to be ap-

plied to physiological facts exclusively. This distinction is opposed to the tendencies of contemporaneous science, whose analyses reduce all morphological facts to physiological facts. Selection, Hartmann says, explains the progress in perfection of an already existing type, within its own degree of organization; but it cannot explain the passage from an inferior degree of organization to a superior one, a passage which always consists in an augmentation of the morphological type; and he gives, as a reason for his argument, that there is no more vitality in one morphological type than in another, and that selection is applicable only to facts that increase the vitality of the organism. All the degrees of organization possessing equal vitality, it is only, Hartmann insists, within the limits of a particular degree that different species or varieties are distinguished by more or less important advantages in the struggle for existence: if Darwinism were true of all species without restriction, there could only subsist one single morphological type in each locality, and, in the millions of years that the vital competition has lasted, all the inferior classes of animals and plants must have been extinguished by the superior classes; there are, in a word, a great number of facts which form part of the plan of the world, and yet are of no service in giving more vitality; such facts, in order to keep themselves in existence, need some other support than that of natural selection and the struggle for life.

We understand how many minds feel a certain repugnance in accepting the daring views of Darwin, so contrary to old associations of ideas. It is as yet nothing more than an hypothetic induction, which is waiting for its experimental verification. But it is no less true that this is the most probable of all the theories hitherto put forth upon the forms of life, and in default of that palpable and decisive demonstration that time only can furnish, we shall at least maintain that this opinion deserves to be preferred to all those still far more hypothetic doctrines which cannot dispense with a supernatural principle.

No doubt Darwinism does not succeed in explaining every thing. It has never assumed to account for the existence of forces, for the origin of those movements which are the source, and as it were the substance of life; it takes into view only their direction and the procedure of their organization. Putting aside the mysterious problem of being, it takes cognizance only of the methods of being. Is this saying that selection is only one of the means employed by a superior intelligence to govern the other forces of the world toward its ends? Nothing permits us to suppose that, for, on the contrary, the peculiarity of selection, in all the cases to which it applies, is to explain order without calling in the aid of intelligence, and as a necessary resultant of the reciprocal action of forces.

We think, with Hartmann, that Darwinism can explain only those facts that relate to the vitality of beings. But what fact is there in living Nature which can be regarded as indifferent from the point of

view of the struggle for life? Can one imagine, in the recesses of an organ, a single cell, a single element, which is not fighting for existence? If there could be one, then there would exist in reality something else than forces encountering forces, and that is a consequence which Hartmann himself could not admit, recognizing, as he does, nothing but forces in the atoms of matter, and explaining, as he does, reality and consciousness by the opposition of contending forces. We shall find him, farther on, maintaining that, when two contrary but equal forces meet, they annul and annihilate each other, and all reality vanishes; and yet the same author, arguing against Darwin, supposes a reality which is not the result of the encounter and strife of forces. For Hartmann, more than any other reasoner, the sphere of selection ought to be coextensive with that of reality, and whenever conflict and selection cease, by reason of the equilibrium of forces, there should be nothing but annihilation. But contradiction, we all know, is the hereditary vice of metaphysics.

In proof that certain facts have no concern with the struggle for life, Hartmann mentions beauty, and especially the beauty of plants, which it would be difficult to explain by selection. Here we find ourselves face to face with German æsthetics, with its mystical theories, and its metaphysical entities. For ourselves, regarding beauty not as a real fact, but simply as a relation between things and our faculties, we do not feel this difficulty. We admit that selection has nothing to do with the matter, because beauty is neither an act, nor an organ, nor a function: it is simply a mode in us of feeling outward objects; it is a sentiment inspired by things which answer to our habits of thought, and correspond with our associations of ideas. There is not, in Nature, any fact which is beautiful only; whatever is beautiful is at the same time an object, and the forces that produce it, produce it, so far as it is an object, and not so far as it is beautiful. We are not speaking of art, in which selection again comes up; and, in fact, if there is no natural selection as to beauty, there may be, in very many cases, artificial or intelligent selection: among animals, and especially as regards man, we know that beauty exerts a certain influence on choice in sexual passion. As to the plant, which cannot choose, we have to take account of natural selection by man, whose culture promotes the preservation of the species most agreeable to the eye; we may even admit a certain selection by insects, which assist the transfer of the pollen, and are perhaps not wholly insensible to size among flowers, to their brilliancy of color, etc.

Can an argument against Darwinism be founded on the equality of vitality among different species? When selection has induced a very considerable difference between two varieties, developing in two more or less opposite directions, it often occurs that these two varieties or species no longer have the same conditions of existence, and cease to compete with each other. The farther apart the types grow,

the more there may exist between them that equality of vitality which is merely the negation of competition. This explains why we oftener remark equal vitality between different species than between varieties of the same species. Certain species even suggest each other, and have mutual need each of the other for their existence. If, for instance, the quantity of vegetables, or of certain animal species which we require for our nourishment, were to decrease, it would necessarily follow that population would diminish proportionately; but that diminution would allow the other species to resume their former development; therefore the equilibrium is maintained of necessity.

As to the possibility of morphological alterations, by the accumulation of individual modifications, Hartmann himself admits that Darwin has cited more than one instance of it, and a marked one in the skeleton of pigeons: he objects, it is true, that there was some aid from art in these different cases. Very true! but that proves that analogous changes are at least possible through natural selection. Hartmann adds, that a pair of teeth, or vertebræ, or fingers, more or less, or a vertebra shaped in such or such a way, are exactly the marks by which zoologists oftenest distinguish species, and yet he says such marks are of no importance in the struggle for life. This seems to us an oversight; for they are precisely those scarcely appreciable modifications which have the greatest importance from the point of view of selection and competition.

Darwin and Hartmann stand at the opposite poles of modern thought. To Darwin belongs the most fertile idea of the age, an idea which upsets all the ancient ways of conceiving the world, and includes the first natural explanation yet given of order, of organization, and of intelligence itself. Hartmann, on the contrary, takes us back to the ancient labyrinths of teleology; between two explanations, one natural and the other supernatural, we have always found him, thus far, pronouncing for the latter. We detect a new instance of this predilection in his way of regarding instinct. Darwinism explains it admirably as an hereditary habit resulting from natural selection; a habit can only become formed and inveterate on condition of its aiming at a result useful for the preservation of the individual and the species; that which is not useful cannot become habitual, or at least not hereditary. Vices can be only individual accidents, or else the race is tending toward extinction; all that flows from the force of things, and there is no call for the supposition that the utility of fact grown into habit must have been foreseen, and willed by a supernatural being. But Hartmann prefers to define instinct as "the conscious will (choice) of a means in view of an end unconsciously willed;" and this he does to raise a necessity for the supposition of an intelligent principle, distinct from conscious intelligence, in the bosom of which he may lodge the seat of these unconscious volitions.

Hartmann's love of the supernatural goes so far as to make him

accept, with the fullest faith, a certain number of extraordinary facts which stand much in need of confirmation, such as the facts of second sight and of artificial somnambulism. He admits the truth of dreams, visions, and presentiments; he cites cases of warnings given by mysterious revelations of coming dangers, of the death of one absent, or of other occurrences taking place at a distance, as in the well-known story of Swedenborg. Nothing is wanting but spiritism and turning tables. It is clear that such facts would justify and even compel the hypothesis of a supernatural principle. If the existence of a superior intelligence in the world can be demonstrated by physical proofs (we are not now speaking of metaphysical proofs), it is not by the spectacle of order and regularity which indicate, on the contrary, the absence of any disturbing or interposing force, but really by abnormal and contradictory facts; in a word, by miracles. Only, it is necessary that the authenticity of such facts should be above all question.

As to what concerns thought itself, we share Hartmann's views on almost all the points of psychological analysis, and only when his transcendental explanations begin do we feel obliged to part company with him. Thus we think, as he does, that the *I* does not make the greater part of its ideas, that its ideas come to it without its volition, and without its consciousness of the causes producing them. But what must be concluded from this, except that intelligence in general is a resultant and not a principle, and that it is simply, as Taine and the later English psychologists have so well shown, the series, the grouping, the *ensemble*, of a multitude of phenomena, the greater part of which have their cause outside of the *me*. Hartmann sets out on quite a different path, and supposes behind my consciousness another intelligence, which elaborates these ideas for me, and imparts them to me ready made; and in support of this theory he invokes the mysticism for which he betrays sympathies that recall the romantic school; he invokes the inspiration of genius, which he holds to be only the revelation of luminous thoughts to certain privileged natures. But is genius any other thing than the combination of those cerebral conditions which permit new relations of ideas to manifest themselves in an intelligence, under the mere stimulus of life, of the organic functions, and of the perceptions?

We remark the production, in history, of a great number of facts which are independent of human volitions. Men set an end before them, and yet the result is quite different from the one they had foreseen and willed. How could it be otherwise, since individual volitions are but elements in the midst of an immense complexity, and all the elements are thwarting, checking, neutralizing each other? Moreover, the struggles for existence and selection explain historic progress as clearly as they do physiological development. But Hartmann prefers, in this instance, as in others, to resort to a metaphysical principle, and imitates Joseph de Maistre, in calling for the interposition of a

providential action, which guides humanity toward an end, sometimes even in spite of human efforts.

At the same time that Hartmann endeavors to prove, by the facts we have just spoken of, the existence of "a psychical principle maintaining itself above matter," he fancies that he has evolved from these same facts the idea of what he calls "the unconsciousness," the idea of an intelligence which has no consciousness of itself, of unconscious manifestations (Vorstellungen), of unconscious volitions. We declare that we have not succeeded in comprehending this idea—it even seems to us self-contradictory. What *is* an idea or a volition without the consciousness of that idea or that volition? Can the idea be any thing else than one form of consciousness, as the volition is another form of it? Hartmann is able to cite facts of intelligence which are outside of the consciousness of the *me*, but without being able to prove that these facts must be unconscious, absolutely and in themselves. Who can even prove to us that the *I* is the totality of the conscious phenomena of the brain? The *I* is nothing more than a series of facts, and may there not be alongside of this series a multitude of facts which become real, without being attached to it by any bond of continuity? For instance, personal character is made up of a great number of conditions, which, without any consciousness on the part of the *I*, modify the direction of its volitions: these facts only make themselves known to us by their influence on the acts and the morals of the individual. But does it follow, from their being unconscious relatively to the *me*, that they are unconscious in themselves? Hartmann's own doctrines, on the contrary, would lead us to allow that the other nervous centres, the spinal marrow, the ganglia, etc., are endowed with their own consciousness; that there is a special consciousness in each cell of a plant or animal, perhaps even in every material atom; in a word, that consciousness coincides everywhere with reality, unconsciousness being outside of real facts. But what is to be concluded from this, except that none of the real facts, which Hartmann has set forth with so many details, offer us the idea of the unconscious? And then what foundation is there for this definition, that "the unconscious is the cause of all those facts, in an organic and conscious individual, which lead us to the supposition of a psychical and unconscious cause?" We will even say that Hartmann seems to us to have succeeded better in widening the sphere of consciousness, than in founding a philosophy of the unconscious.

If we put ourselves the question, What is the real motive that determined him to attribute unconsciousness, rather than consciousness, to the supreme intelligence, to God? we find only an *a priori* reason, drawn from the idea that evil rules the world: "If, at the time of the creation of the world, there was in God any thing like consciousness, the existence of the world would be an inexcusable cruelty, and the development of the world a useless absurdity." Hartmann finds him-

self driven to suppose God unconscious, to escape supposing him wicked. "This consideration," he says, "is decisive against the admission of consciousness in God." But stay!—if God has not the consciousness of what there is evil in the world, Hartmann argues, on the other hand, that he has the idea of it (the Vorstellung). Does not this idea suffice, as well as consciousness could (in our view they are exactly the same thing), to pledge the Divine responsibility?

EVOLUTION AND THE SPECTROSCOPE.

By F. W. CLARKE.

MEN of science may be divided into two great classes—thinkers and observers. And, although both classes are often represented in one individual, the distinction between them is practically valid. For, in classifying mankind, no sharp boundaries can be drawn. The observer, on the one hand, contents himself with merely ascertaining facts, and rarely deduces more than the simplest and most obvious conclusions from them. He is in some measure an intellectual miser, who accumulates, but never uses. It is the thinker, however, who gives shape to science. His generalizations make true science possible. To him, a discovery amounts to something more than its mere self, and is valuable, like a choice seed, largely for what it may become. He ranges facts into series, gives each series its proper place in a science, clusters the sciences into groups, and, studying these groups with reference to each other, and to the grand problems with which thought is always busied, seeks to arrive at higher conceptions of the universe, and of the essential unity of all material things. At the present day this method of comparison has led to the announcement of the philosophy of evolution; a philosophy which places the physical world in a clearer light, and classifies a greater number of facts, than any other scheme that human earnestness and ingenuity ever devised. Surely it is worth while for us to study all great discoveries with reference to their bearings upon this philosophy.

Probably none of the many remarkable discoveries of the nineteenth century are more important or more striking than those achieved by means of the spectroscope. It is now less than fifteen years since this famous instrument was devised, and already it ranks in importance side by side with the telescope and the microscope. New fields of research have been opened, which, widening ever since, show as yet no signs of approaching limits. Chemical analysis has been simplified, many optical researches facilitated, and four new metals discovered. Our knowledge of the sun and stars has in some

respects been more than doubled. Problems which were deemed insoluble, have been settled with the greatest ease. The magnitude of the discoveries already made leads us to expect still greater revelations in the future. Let us see what the spectroscope has to say for the philosophy of evolution.

Among the doctrines held by evolutionists, the all but proved Nebular Hypothesis occupies a very prominent position. Originating with Kant more than a century ago, and afterward furnished with secure foundations by Laplace, it has since striven for complete acceptance with ever-varying strength. According to this hypothesis, our solar system began existence as a nebulous cloud of incandescent vapor, which, rotating about a centre, and cooling as it revolved, cast off rings of matter that gathered into globes and became planets, while the central portion, undergoing less change, formed the sun. A vast weight of physical and mathematical evidence supported this theory, and the nebulæ seen in different parts of the heavens lent to it the confirmation of analogy. From the first, the hypothesis was strong.

But soon doubts began to arise. Larger and more powerful telescopes were constructed, and many nebulæ were resolved into clusters of stars. Astronomers began to hope that all these bodies might be similarly resolved, and the nebular hypothesis lost a little ground. But the spectroscope came apparently to the rescue. In the skilful hands of Mr. Huggins, the narrow slit was made to receive the light of several unresolved nebulæ, and nebula after nebula gave up its secret to the observer. Some yielded spectra, consisting of from one to four bright lines, while others gave continuous bands of feeble light. The former class told the story. Spectra like theirs could belong only to the light emitted by incandescent gas, and therefore of such material, true nebulous vapor, these distant bodies consisted. But even more was revealed. The bright lines were characteristic of two well-known substances, nitrogen being the more distinct of the two, and hydrogen the less clearly visible. No other elements could be detected, nor could any good reason be found for supposing others to be present. But the main fact of the existence of genuine nebulæ was fairly demonstrated, and the nebular hypothesis received a great accession of strength. To-day it almost commands acceptance, although it is capable of being made much stronger. Even the evidence which analogy might offer in its favor is far from complete. We must look to the spectroscope for its completion.

In this connection a great variety of interesting questions suggest themselves. We assume that our planet originated from a gaseous cloud by a slow process of condensation and cooling, and point to the visible nebulæ to confirm our views. Now, in evolving a solar system from a nebula, a long series of changes would necessarily occur. We see the extremes of such a line of development, and also a few of the intermediate links. And we are at once led to ask whether we can

hope to find existing to-day, among the heavenly bodies, examples of all the stages of evolution through which matter must pass in forming solid globes from shapeless clouds of incandescent vapor. The task will be a difficult one, but not hopeless. We have much material to begin upon, and can safely look to the spectroscope to furnish us with an abundance in the future. If the work can be done, the nebular hypothesis will become so well grounded that we are scarcely able to conceive of any possible arguments which could afterward disturb it.

In beginning upon such an inquiry, we must start with a consideration of the nebulæ themselves. And, at the outset, their varieties of form, and the visible changes which they undergo, offer strong suggestions of processes of evolution actually going on. The spiral nebulæ hint of rotary motion, and some annular forms speak to us of rings of vapor from which planets are yet to grow. In the double nebulæ we see future pairs of suns, companion stars; and in every true nebula are signs of condensation in the brighter portions. The nuclei which are so common may be the germs of central luminaries, around which systems like our own are yet to revolve. But all these observations are due to the telescope. We have to consider what the spectroscope has done.

Now, as regards spectroscopic work, the nebulæ may be divided into three classes: First, those which give spectra consisting only of bright lines. Secondly, nebulæ whose spectra are continuous. And, in the third place, the nebulæ described by Lieutenant Herschel, which are apparently intermediate between the other two classes, and furnish spectra of bright lines upon a continuous background.

The nebulæ of the first class I have partly described. They consist mainly, if not wholly, of two common gases, nitrogen and hydrogen. But gases give somewhat different spectra under different circumstances of temperature and pressure; and the spectrum of a nebula indicates that the gases of which it is composed are in a highly-rarefied condition, and at a temperature *considerably lower than that of our sun!* Of this we are tolerably sure, though perhaps not absolutely certain.

The nebulæ whose spectra are continuous speak to us with less certainty. Lord Oxmantown has shown that the resolved nebulæ—those which are known to be mere star-clusters—give this kind of spectrum, as do also most of those which appear to be resolvable. Accordingly, it is reasonably inferred that all the nebulæ of this class probably belong to the resolvable order; but here is where a slight doubt may arise: gases, under great pressure and at a high temperature, give continuous spectra; possibly, then, some of these nebulæ may consist of gases under just such conditions. Here is a problem yet to be solved. The third class of nebulæ may, perhaps, strengthen this latter view. Their spectra are intermediate between those of the other classes. It

may be that a more careful study will show them to be gaseous, with their spectral lines in a state of transition to the full continuous spectrum; but this is little more than bare conjecture at present; for the published descriptions of these nebulæ are too incomplete to admit of very satisfactory discussion.

This consideration of nebular spectra plunges us at once into a sea of difficulties. We say that the sun and planets were formed by condensation and cooling from incandescent vapors, and hail the nebulæ as confirming this opinion. But could a sun be evoked, by cooling, from a body less hot than itself? Moreover, the sun is known to contain at least sixteen elements and probably many more. Were these developed from a nebula containing only nitrogen and hydrogen? Or did the original nebulæ differ in constitution? All those which the spectroscope has analyzed are chemically alike. We know nothing of any whose constitution differs in this respect from theirs; and, therefore, if we point to them as confirmatory of the nebular hypothesis, we are compelled to ask this portentous question: Did our planet, with all its chemical complexity, arise, by a slow process of evolution, from a glowing cloud of but two familiar gases? Upon our answer to this question depends largely the value of our spectroscopic confirmation of the great hypothesis. The safety of the hypothesis itself is not involved; merely that of this one argument in its favor. We can easily conceive of more complex nebulæ, which could give rise to systems like ours, although we know nothing of them. And, if we interpret the spectra of some nebulæ of the second class as due to gases at very high temperature and pressure, the difficulty regarding the heat of our sun will be easily gotten over.

Let us consider the question suggested, as to the possible evolution of complex from simple matter. It is easy to speak out boldly, in an *ex-cathedra* manner, and say that an affirmative answer to such a question would be absurd; but dogmatism of this sort is, in the highest sense, unphilosophical and foolish. We do not know but that the evolution of one element from another may be possible, under circumstances over which we have as yet no mastery; indeed, such a view would have many points of probability about it. Although unsupported, it is quite strongly suggested by evidence. The demonstrated unity of force leads us, by analogy, to expect a similar unity of matter; and the many strange and hitherto unexplained relations between the different elements tend to encourage our expectations. These elements, which seem to-day so diverse in character, may be, after all, one in essence. This idea is philosophically strong, but waits for experimental evidence to support it. At present, it can neither be discarded as false, nor accepted as true. But what an addition the proof of such a doctrine would bring to the philosophy of evolution!

Now, although questions like these cannot be settled by any evidence which we are likely to obtain for many years to come, specula-

tion upon them is not altogether unprofitable. The time spent in conjectures and surmises is not wholly wasted; for it is impossible to follow up any of the lines of thought thus opened, without reaching some valuable suggestions, which may pave the way to new discoveries. New truth, in one direction or another, is sure to be reached in the long-run. So, then, we may proceed to theorize in the most barefaced manner, without entirely quitting the legitimate domain of science.

It is plain that the nebular hypothesis would be doubled in importance, and our views of the universe greatly expanded, if it could be shown that an evolution of complex from simple forms of matter accompanied the development of planets from the nebulæ. Evolution could look for no grander triumph. For the evidence to support such a theory, we must depend mainly upon the spectroscope. Let us continue upon our task of finding the intermediate links between the two extremes of planetary growth, and see whether, as we ascend in the line of change, an increased chemical complexity can be observed. Upon this theory, the planets should contain more elements than the sun; the sun more than some of the less advanced among the fixed stars; and these, in turn, should be more highly organized than the nebulæ. But we must not fail to remember that we are merely speculating, and that the spectroscope, in telling us of the presence of certain substances, does not give us accurate information with regard to the absence of others. In this investigation, we can look to the spectroscope only for hints, not certainties. Difficulties will abound in our path, and, in a paper of this length, we cannot stop to scrutinize them closely. We must bridge many chasms with guesses.

The evidence concerning the constitution of the fixed stars has been furnished chiefly by Secchi and Huggins. The former observer, favored by Italian skies, has done, perhaps, the major portion of the work, and has given us a classification of these bodies. According to Secchi, the stars may be divided into four classes, as follows:

In the first class, which is by far the largest, we find most of the *white* stars, Sirius, Altair, Vega, Regulus, and Rigel, being especially prominent. These give spectra characterized by the intense development of the four hydrogen lines, which stand out with great distinctness upon a background of the seven primary colors. Lines belonging to some of the metals, particularly to sodium, magnesium, and iron, are also visible, but are exceedingly faint in comparison with those of hydrogen. The distinctness of this element, as compared with the faintness of the metallic lines, is characteristic of the stars of this type. The absence of bands, indicating an absorptive atmosphere, is also noteworthy.

In the second class of stars we find our sun, Arcturus, Aldebaran, Capella, Pollux, Procyon, and many others. Here we have spectra in which the lines of the metals are apparently more numerous, and certainly more distinct, the hydrogen being less conspicuous. In Alde-

baran, Mr. Huggins detected sodium, magnesium, calcium, iron, bismuth, antimony, tellurium, mercury, and hydrogen.

The third class, in which are some stars of a red color, is comparatively small in numbers. Alpha Orionis or Betelgeux, Alpha Herculis, Beta Pegasi, Mira beti, and Antares, are good examples of this type. Their spectra, as a rule, resemble the spectrum of a solar spot, and sometimes contain bright lines. Hydrogen is still present, but so difficult to detect that, at first, it was supposed to be wanting in the spectrum of Betelgeux. But, in a state of combination, as aqueous vapor, it has been found in the stars of this order, and, most notably, in Antares. In the spectrum of Betelgeux, Mr. Huggins observed lines belonging to magnesium, sodium, iron, calcium, and bismuth.

The stars of the fourth type are very inconspicuous, but give quite peculiar spectra, consisting chiefly of three bright bands, separated by dark spaces. Such a spectrum suggests that of carbon, but really tells us nothing, as yet, of the constitution of these stars. We must, therefore, leave them out of account in our speculations. It would be easy to theorize about them, only the theories would find no place in our argument.

Now, taking the spectra of stars of the first, second, and third classes as a basis for our speculations, we have quite decent evidence of a gradual increase in chemical complexity. And, if we bring the nebulæ into line, we can devise a very neat progressive series of development up to the solid planet. Beginning with a nebula consisting mainly of nitrogen and hydrogen at low temperature and pressure, we can easily conceive of several ways by which it might gain great accessions of heat, and give a bright, continuous spectrum. A collision with meteoric or cometary matter would account for such an increase of temperature. But, given a nebula which is sufficiently hot, and from which a sun *might* be evolved by cooling, what shape will our speculations assume? This intensely-heated body undergoes a certain condensation, rings are thrown off from it, and a nucleus appears, which soon becomes a star or sun of the first type. Hydrogen still predominates in its constitution, but metals begin to show themselves, though very faintly. But the cooling continues, and gradually the hydrogen lines become fainter, the metallic lines stronger, a larger number of substances are detected, and we have a sun of the second class. By another slow transition, chemical action, as we recognize it, begins to set in. The hydrogen lines disappear; aqueous vapor is formed; spots, like those of the sun, which are probably centres of chemical activity, become more and more abundant, and the star enters the third order. As the spots accumulate, the star becomes more decidedly a "variable," and, after violent and prolonged convulsions of its surface, solidity is reached, the emission of light ceases, and a planet is formed. Some volcanic heat, however, yet remains; but this slowly dies away, the volcanoes become extinct, and, at the end of the

line of change, we have a body like our moon, dead and sterile. And here our speculations end. What next ensues, no one can say. We are seeking the past history of our planet, not looking into its future.

Now, a paper of this sort should always contain a summary of the steps by which its conclusions have been reached. Beginning with the nebular hypothesis, as it is commonly understood, we saw that it was philosophically strong, was supported by much evidence, and opposed by none. Bringing the spectroscope to bear upon it, we found that true nebulæ undoubtedly exist, and that there is tolerably good proof of different degrees of complexity among the fixed stars. Notwithstanding these differences, however, we know that the universe is built throughout of essentially the same materials. In order to bring unity out of this diversity in the constitutions of the heavenly bodies, we arranged a series of development, from nebula to planet. This made it apparent that an evolution of matter from lower to higher stages might have accompanied the formation of planets and suns; an idea which was suggested also by physical analogies, and which had decided elements of philosophical strength. And thus we gave to the nebular hypothesis the somewhat novel form which it has received in our speculations. Without our additions, it could derive no real support from the spectroscopic evidence adduced in its behalf. The known nebulæ are simple, our systems of suns complex. By assuming the evolution of matter, these difficulties cease to exist, and we have a coherent hypothesis, in which the evidence offered by the spectroscope is used to good advantage. To be sure, although it is in harmony with many observed facts, it is open to many objections. And yet we can admit its probability, to a certain extent, without giving it the adherence of actual belief. Such theorizing is profitable, partly because it aids us in making out the limits of our present knowledge, suggests to us new paths of investigation, and, by uniting masses of different ideas, helps the mind to handle more easily the facts and conceptions with which it has to deal.

But, when one is fairly started on a line of thoughts, it is hard to come to an end. Problem after problem, theory after theory, law after law, crowd forward for inspection. If we assume one hypothesis to be true, a hundred others rush in upon the mind, and demand consideration. From every one of these a host of interesting conclusions can be drawn, each suggesting another, until the brain grows weary of action. The present case is no exception to the rule. Objections must be answered, consequences foreseen, demonstrations sought. In an article of this scope few points can receive due attention. Let it then suffice, in closing, to say that science has done so much in the past that we can justly expect almost any achievement in the future. And perhaps, in days yet to come, an evolution of matter may be experimentally be brought about, and our speculations of to-day proved to be not altogether foolish.

DR. LIVINGSTONE.

By L. J. PROCTER.

DAVID LIVINGSTONE was born at Glasgow early in the present century. His grandfather was originally the occupier of a small farm in Ulva, one of the Hebrides, but, owing to the requirements of a large family, found himself obliged to quit his island home to seek employment at the Blantyre cotton works on the Clyde, above Glasgow. Livingstone's father and uncles having been fairly educated, easily obtained situations as clerks at the factory, though the former appears to have relinquished his employment with the pen, and to have occupied himself during the later years of his life in keeping a shop as a tea dealer in Glasgow. He died a member of the Independents in 1856, but brought up his children in connection with the old Kirk of Scotland.

At ten years of age, David Livingstone was put to work as a "piecer" at the Blantyre factory. Even at this early date his character was remarkable for a gravity, and steady, plodding earnestness. Reading took the place of ordinary amusements; and, after a hard day's work, the boy would often sit at his studies so far into the night as to call for his mother's peremptory interference. To economize time, he accustomed himself while at work to place an open book on a portion of the spinning jenny, and catch sentence after sentence as he passed backward and forward in front of it, quite undisturbed by the noise of the machinery. An evening-school was made to help in his education, and it may well be supposed no leisure time was wasted. While still a youth, the truths of religion took a deep hold of his mind; and under the feeling thus produced, "in the glow of love," as he says, "which Christianity inspires, I soon resolved to devote myself to the alleviation of human misery." "Turning this idea over in my mind," he adds, "I felt that to be the pioneer of Christianity in China might lead to the material benefit of some portions of that immense empire; and therefore set myself to obtain a medical education, in order to be qualified for that enterprise." Being promoted at nineteen to higher work in the factory, the increased wages he received enabled him, by working during the greater part of the year, to support himself at Glasgow while attending the medical, Greek, and divinity classes, which were held in the winter. By the advice of friends, he was induced, though reluctantly, to offer himself for the service of the London Missionary Society, and was accepted. His admission as a "Licentiate of Faculty of Physicians and Surgeons" completed his preparatory labors. Just at the time, however, the opium war broke out in China, and this presented an obstacle so great as to render it

advisable that he should abandon his original design, and look elsewhere for a sphere of enterprise. It was soon offered. Mr. Moffat, another of the London Society's missionaries, was laboring successfully in Southern Africa among the tribe of the Bechuana. Livingstone heard of this; and, as both the scene and the work were attractive, he resolved to join him.

Accordingly in 1840, with the full approval of his Society, he left England for Kuruman, Mr. Moffat's station. There he spent the first three years. In 1843 he moved to Mabotsa, some three hundred miles to the northeast, where, in the effort to help his Bakatta *protégés*, the memorable encounter with the lion occurred, which so nearly proved fatal to him. In 1844 he married the veteran missionary's daughter. Having made a friend of Sechele, chief of the Bakwains, he ultimately removed to his country, and built a station with his own hands, near a small stream called the Kolobeng.

Some years pass in hard and successful work, and then Livingstone renounces his life as a stationary teacher; and, though never entirely relinquishing his missionary character, assumes that of an explorer, by which he is best known. The change came about in this way:

To the southeast of Kolobeng lay the Kashan Mountains, to which a number of Dutch Boers, fugitives from English law, had migrated, and formed a small republic. Having appropriated their territory, they had compelled the natives themselves to live, if not in absolute slavery, yet under a system of unpaid labor very closely allied to it. Livingstone, with his missionary views, was of course looked upon as an interloper, and hated in a corresponding degree. To add to the grievance of the settlement at Kolobeng, his subsequent discovery of Lake Ngami had encouraged traders to advance from the south, who, by giving the natives ideas about commercial matters they never had before, tended to raise disaffection toward themselves. The result was a determination on the part of the Boers to make a raid on the Bakwains, which a report that the latter were well armed with guns and cannon (an amusing myth about a black pot of Livingstone's) alone prevented. They then tried to get the governor at the Cape, Sir G. Cathcart, to interfere, and negotiations which followed ended in a treaty far more favorable to the natives than to themselves. In spite of this, however, an attack was made by the Boers on Sechele and the Bakwains in 1852, in which Livingstone's house was burnt down, and all his property destroyed, while he was absent on a journey to the Cape.

This opposition was very provoking to Livingstone; and the determination to carry out his plans for bettering the condition of the natives set him at work forthwith to open up the country northward. In company with two English gentlemen, Mr. Oswell and Major Vardon, the great Kalahari Desert was crossed, and Lake Ngami discovered, in August, 1849. Livingstone's opinion of this country de-

serves notice: "Not only the natives," he says, "but Europeans whose constitutions have been impaired by an Indian climate, find the tract of country indicated"—the southern borders of the Kalahari—"both healthy and restorative . . . . Cases have been known in which patients have come from the coasts with complaints closely resembling, if they were not actually those of consumption; and they have recovered by the influence of the climate alone."

A subsequent journey in the same direction brought him to the town of Sebituane, chief of the Makololo, from whom he met with a most cordial reception. Unfortunately, the chief fell sick and died shortly after his arrival; but the promise of assistance made before this occurred was confirmed by his successor, a daughter, Ma-Mochisane. In order to confer with her on the matter, Livingstone made a journey to Shesheke, where she lived, 130 miles to the northeast, in company with Mr. Oswell. It was on this journey that they discovered the Zambési, toward the end of June, 1851, even then, the dry season of the year, a magnificent stream 300 or 400 yards broad. In defence of his claim to the discovery, Dr. Livingstone says: "The Portuguese maps all represent the Zambési as rising far to the east of where we now were; and, if ever any thing like a chain of trading-stations (as is asserted) had existed across the country between the latitudes 12° and 18° south, this magnificent portion of the river must have been known before." The discovery was indeed important; and, impelled not only by the prospects it presented, but by the remembrance of his difficulties at Kolobeng, Livingstone decided to explore the river thoroughly, and meanwhile send his family home to England.

The journey undertaken with this view commenced in the early part of June, 1852, and "extended from Capetown, at the southern extremity of the continent, to St. Paul de Loando, the capital of Angola on the west coast, and thence across south Central Africa in an oblique direction to Quelimane in Eastern Africa." Besides geographical research, Livingstone tells us that his object was to find if he could "a healthy district that might prove a centre of civilization, and open up the interior by a path to either the east or west coast."

Glancing rapidly along his route, we are to see our traveller first at Kuruman, where the panic in the country on account of the attack on Kolobeng delayed him. Then at Linyanti, capital of the Makololo, where Sekeletu now reigned in place of his sister Ma-Mochisane, showing himself, like his predecessors, favorable to Livingstone. Then with a large body of Makololo, provided by the chief, on December 27, 1853, at the confluence of the two streams Leeba and Leeambye, where we pause.

The Leeambye—also called the Kabompo and Zambési—is a large river 300 yards wide, flowing from the eastward, while the Leeba, 250 yards wide, comes from the N. N. W. The junction of the two forms Livingstone's Zambési, lat. 14° 10′ 52″ S., long. 23° 35′ 40″ E. Lake

Dilolo, a small body of water, reached February 20, 1854, is the source of the Leeba. It was only on his return that Livingstone ascertained this. But the courses taken by the different streams he crossed struck him; and the observations he made on his journey back impressing him with the conviction that the Dilolo country was the water-shed of the streams running east and west, led him to confirm the theory of Sir R. Murchison, of which he had not heard at the time, that the form of the interior of the South African Continent is that of an elevated, saucer-shaped plateau. In other words, that the country is gradually depressed toward its centre, sloping from an inner environing mountain-ridge toward which the land rises from the coast. The western ridge was crossed at a spot called Tala Mungongo, lat. 9° 42′ 37″ S., and, by carefully noticing the course of the various streams flowing thence to the centre, and forming his judgment from what Arab traders had told him—subsequently confirmed by his own observation—that the rivers set inland from a similar ridge on the eastern side of the continent, the conclusion forced itself on Livingstone's mind, that these river systems, uniting at last, pass out to the north and south in two main drains; the northern finding its way to the Atlantic as the Congo on the west coast, and the southern to the Indian Ocean as the Zambési on the east. The configuration of the country alluded to will account for the course of the Leeba from the lake being about S. E., while the Leeambye joins it flowing west from the eastern ridge of the central plateau. But Livingstone also speaks confidently of "a sort of elevated partition in the great longitudinal valley" between the latitudes about 6° and 12° S. It would not be fair to him to suppress the fact that, considering this peculiar configuration of the country, and hearing from some Zanzibar Arabs of the existence of a lake Tanganyenka (Tanganyika) and Nyanja (Nyassa) to the east of Londa where he then was, he was led to the probable conjecture that the region about them would be found to be the water-shed of the Nile to the north, as it was that of the Zambési to the south. Thus his sagacity brought him to anticipate the existence of facts which have since been confirmed by the travels of Burton, Speke, and Grant, and Sir S. Baker; and which only remain to be thoroughly investigated and defined in the completion of those researches the exciting story of whose partial accomplishment we have recently heard.

A few words must dispose of Livingstone's westward journey. Passing various tribes as he wends along, chiefly on oxback, accompanied by his faithful Makololo, he encounters no opposition, but the contrary, till he enters the territory of the Chiboque. There, however, he gets on the track of the Mambari, or half-caste Portuguese slave-traders, from whom the native chiefs exacted heavy tribute, and the hostilities with which he is threatened, on his stanch refusal to submit to their impositions, were avoided simply by his firmness and tact. On his arrival at Loando, May 31, 1854, he was well received by the

Portuguese, whose kind treatment did much to restore his health, which had been impaired by fever, and the poor food, chiefly manioc-root, on which he had been obliged to live. But his task was bootless. The country was unhealthy. The coast tribes were inhospitable. Wagons would be impracticable among the interminable forests, marshes, and rivers. The westward route being thus out of the question, instead of availing himself of the offer of a passage home from the officers of H. M.'s cruisers at Loando, Livingstone determined to retrace his steps, and seek a path along the Zambési to the east.

In August, 1854, he is once more at Linyanti; on November 3d, starting down the Zambési with a large retinue of Makololo.

The country beyond Linyanti is greatly infested by the "tsetse" fly, the bite of which, fatal to oxen, horses, and dogs, is perfectly harmless to man, as well as to goats and sheep, and wild animals. After its bite is received, the victim gradually pines as if seized with consumption, and in a longer or shorter time dies. There is no cure for it known. In appearance the "tsetse" resembles the honey-bee, and is about the size of the common horse-fly. It is common throughout the whole of Central Africa, and infests certain well-defined districts, usually those frequented by game; numbers may be found in a particular spot, and yet a few yards farther on not a singly fly is to be seen. It only bites in the daytime.

Starting at night, therefore, to get safely through the "tsetse" tract, on November 4th Livingstone arrived at the island of Kalai, where the rapids commence above the "Victoria Falls," as he loyally named them. They are known among the natives as "Mosi oa tunya" (Smoke does sound there). Nothing can be grander than their appearance, which is perhaps unique. Columns of vapor, darkening upward from a white base, first become visible, rising at distinct intervals like jets of smoke in the far distance. The broad stream sweeps along, its surface dotted in every direction with beautiful green islands, and then the vast body of water is seen to descend suddenly into a deep perpendicular fissure 180 yards wide, extending across the entire bed of the river, and is lost to view. Looking down from the brink opposite, masses of dense white vapor conceal the seething volume of fallen water below, from which feathery columns of spray like those described, rainbow-covered and the source of ceaseless showers, perpetually ascend far up into the air. Passing eastward (the river here flows north and south), along the edge of the cleft in front of the falls, the fissure is seen to extend, from a gap near the end, with still narrower dimensions in a zigzag course, down which the whole mass of Zambési water, compressed into a deep, swift column, rolls along, boiling and foaming, till it finds an outlet at a lower level. The rock through which the chasm runs is a dark-brown basalt, covered at the projecting angles, and wherever there is root-hold, with a dense growth of tropical vegetation. The length of the fissure into which the river

falls is, by a measurement made in the year 1860, rather more than that number of yards; and the depth, from its edge to the surface of the basin water, about 400 feet. On account of clouds, Livingstone was unable to take the position of the falls; but Kalai, a few miles above (north) is, according to his observation, in lat. 17° 51′ 54″ S., and long. 25° 41′ E.

Passing the confluence of the Kafue, on January 14, 1856, he reached that of the Loangwa, where are the ruins of Zumbo, formerly a Portuguese settlement, and probably the farthest point inland to which they have penetrated from the east, long. 30° 32′ E. Crossing from the north side of the Zambési, along which he had hitherto been travelling, on February 6th, he entered the extensive district of Chicova, where silver-mines were said to have once existed. After examining the geological structure of the country—a soft gray sandstone—he was unable to meet with traces of silver; but crossing some dikes of basalt running north and south, "the sandstone," he says, "is then found to have been disturbed, and at the rivulet called Nake we found it tilted up and exhibiting a section which was coarse sandstone above, sandstone flag, shale, and lastly, a thin seam of coal." This seam, it is true, was not traced far, being displaced by a fault formed by a dike of basalt. But its existence can hardly be deemed an unimportant matter, especially when it is considered that the discovery was made in the very centre of a cotton-producing district, that iron is plentiful in the hills to the north, and that, if, as Livingstone thinks, silver may not prove to be one of the products of the country, gold certainly is, specimens of which the writer has in his possession. That the Portuguese of the lower settlements have not availed themselves more of the advantages thus offered them, is owing much to their indolence and want of enterprise, but more to the hostility of the tribes of these districts, who vigorously oppose any attempts to advance into their territory. A considerable quantity of gold, however, comes into their hands, though it is all obtained from natives living on the borders, who bring it to their settlements. The gold in the form of dust is put into goose-quills, and one quill is sold for twenty-four yards of calico. A singular superstition keeps down the produce. The natives believe the earth to consist of a thin, flat, pancake-like crust of matter, poised in space; and, for fear of breaking through this crust, and falling headlong into the fathomless depths that they suppose yawn for them below, they will never venture to dig deeper than the level of their chin. Whenever a flake or nugget of gold is met with, it is put back into the earth again, under the impression that it forms the seed of the gold!

Striking away from the river southward, Livingstone failed on this occasion to see the rapids of Kebrabasa, 50 miles above Tette. These rapids no doubt present a formidable barrier to the navigation of the Zambési—especially at one point where the whole volume of

the stream, compressed within the limits of a few yards, rushes down with tremendous force between high perpendicular banks of solid rock. But, from the Victoria Falls to the central Luabo mouth-branch, there is nothing else in the shape of hindrance except shoals, and these are only troublesome at the dry season of the year.

Tette, in native momenclature Nungwé, the farthest Portuguese settlement westward, was reached safely on March 3d. The commandant, Major Sicard, received the travellers kindly, and, on hearing the account of the coal discovered at Chicova, mentioned the fact of the existence of five other seams lower down. They were found on the banks of a small river, Lofubu, the visible width of the largest seam, according to Livingstone's measurement, being 58 inches. The whole of the district two miles below Tette proved to be carboniferous; and, if rumor counts for any thing, it extends into the Maravi country far to the north in the region of the lakes.

But the protracted journey is drawing to a close. Passing the Lupata gorge, Senna was reached April 27th. Morambala and the Shiré mouth, May 11th. Thirty miles below, Shupanga. It was here Mrs. Livingstone died of virulent fever, six years after she had joined her husband from England, on April 22, 1862. She lies buried under a fine baobab-tree, close to a modern Portuguese house, and a simple white monument marks her grave. From Mazaro, at the head of the Delta, down the Mutu River to Quelimane, and so the east coast is touched at last, May 26, 1856. A few weeks after, H. M. S. Frolic anchored off Quelimane, and, giving him a passage to Mauritius, the traveller embarked in a steamship of the Peninsular and Oriental Company, and on December 12th, landed in England.

Livingstone was the observed of all observers after his return. The feeling regarding him amounted to enthusiasm; and the eagerness with which his book was read, published in 1857, proved the interest that was taken in all he had done. A high estimate was formed of his abilities; but a still higher one, perhaps, of the qualities he had displayed, the energy, the perseverance, the tenacity of purpose, combined with powers of endurance and a courage and activity that certainly revealed a man of no ordinary calibre. Nor was the integrity of his personal character forgotten. On what just grounds this opinion rested, is proved by the fact that after a lapse of more than fifteen years, in spite of severe criticisms, and not a few hard words, his reputation stands as high as ever. And what had he done? He had overthrown the belief which previously existed, "that a large part of the interior of Africa consisted of sandy deserts into which rivers ran and were lost." He had filled up considerable portions of the map of Central Africa, lying between the 15th and 28th parallels of S. latitude. A splendid river was found crossing nearly two-thirds of the continent, and he had accomplished the work of tracing it down to its outlet with the hope of its becoming a path for the missionary and the mer-

chant. He had shown, too, that the African, with all his faults, was open to the influence of reason, truth, and kindness, that he was capable of improvement, and often eager for it: while all that he wrote of such chiefs as Sechele and Sebituane had corroborated the opinion of every unprejudiced observer that the country could produce men of a far higher stamp than was generally believed.

And now he might have rested. Most men would; but not Livingstone. Feeling more than ever, after his experience on the Zambési, the enormous evils of the slave-trade which prevails along its banks; feeling, too, that the best corrective was to go with commerce and civilization as the handmaids of religion, he endeavored, by public speeches at most of our principal places, to increase the interest in the country his return had excited. At Manchester and Liverpool a strong feeling was aroused among the mercantile and cotton-manufacturing communities; and on the side of religion the universities embraced his cause. Perhaps he never created a deeper impression than at Cambridge, where he concluded a telling speech in the Senate-House, before the leading members of the university, in these words: "I know that, in a few years, I shall be cut off in that country which is now open. Do not let it be shut again!—I go back to Africa to try to make open a path for commerce and Christianity; do you carry out the work which I have begun. I leave it with you!"

There was no resisting such an appeal. It went abroad, and Englishmen were stirred. And they were stirred to a depth that impelled them to come forward, as they heard the man and felt what he was. The Government, under Lord Palmerston, made a liberal grant of money, and furnished him besides with a small steamer to aid him in his further researches. To give him influence with the Portuguese, he was appointed H. B. M. consul at Quelimane. An expedition was formed, composed of picked men, who, as well as assisting Livingstone in the direct objects of his undertaking, were to examine and report on scientific matters. This object, as concisely stated in Livingstone's second book, was "to explore the Zambési, its mouths and tributaries, with a view to their being used as highways for commerce and Christianity to pass into the vast interior of Africa." The expedition left England in H. M. S. Pearl, on March 10, 1858; and in the following May the little steamer Ma-Robert—Mrs. Livingstone's Makololo name—was put together and launched in the Kongone mouth of the Zambési.

But, while this was all doing, the universities did not forget Dr. Livingstone's legacy. Oxford, in addition to the Glasgow M. D., recently conferred, had given him the honorary degree of D. C. L.; but she showed much more how she appreciated his merits by uniting with the other universities to promote the religious objects he had in view. His first work in the Ma-Robert was to ascend the Shiré, and discover a beautiful region along its banks to the eastward, which he strongly

recommended, in subsequent letters home, as a field for missionary enterprise. In the same letters he referred to the organization of a mission, which, he suggested, should consist of a missionary bishop as leader, a staff of clergymen, and a small band of laborers and skilled artisans to instruct the natives in industrial work. This advice was acted upon. The then Bishop of Oxford, Dr. Wilberforce—suitably to the prestige of that honored name—took an active part in establishing what was afterward known as the "Universities' Mission to Central Africa." The Rev. C. F. Mackenzie, Archdeacon of Pieter-Maritzburg, in Natal, was chosen as bishop; and, £17,000 having been subscribed, of which a large portion was contributed by the manufacturing towns, the mission left England on October 6, 1860. After Bishop Mackenzie's consecration at Capetown, on January 1, 1861, he set sail with his companions for the Kongone mouth of the Zambési, in two parties, on board H. M. ships Sidon and Lyra. The Ma-Robert had proved too weak for her work, and, besides carrying the missionaries, the Sidon had the task of taking out the Pioneer in convoy, a new and larger steamer granted to Livingstone by Government. Arriving off the Kongone early in February, they found the doctor with his party waiting for them, having just returned from the Makololo Country, where he had gone to take home the men he had been obliged to leave at Tette, in 1856.

Dr. Livingstone threw himself into the plans of the missionaries, and, without absolutely identifying himself with their work, gave it his hearty support and coöperation. The Pioneer was offered for their passage up the rivers Zambési and Shiré; and the proposal that he should himself accompany them to the place where they were to settle, near Lake Shirwah, was accepted with even greater satisfaction. This good office accomplished, he proceeded with his own work of exploring the southern end of Lake Nyassa (lat. 14° 25′ S., long. 35° 30′ E.), discovered, like Lake Shirwah, a few miles S. S. E. of it, in 1859.

Parenthetically: a figure of medium height, the tough, wiry frame denoting great powers of endurance, the left arm slightly shortened, recalling the perilous encounter with the lion; firm-set features, weather-beaten and browned, though not roughened, by exposure, passive and thoughtful rather than demonstrative; the eyes' keen glance, and a rapidly-changing expression, betraying furtive enthusiasm; a low voice, winning address, manners quiet, frank, and unaffected, even reserved; such was David Livingstone as he is remembered in his favorite dress of rough blue naval cloth, the jacket short, and the low cap, of the same material, surrounded by a broad silver band. Nor is it easy to forget the kindliness of disposition, and the readiness to give sympathy wherever there was zeal, though hesitation or a self-sparing timidity was derided as much as it was despised. Full of courage and self-reliant, he expects to find something of a like spirit in others; and he gives them credit for it, never assuming backwardness or incapacity,

but sternly meeting and dealing with it when its existence is perceived. With a fund of quiet humor—and sarcasm, too, if he pleased—Livingstone possessed a keen sense of the ridiculous, and entered thoroughly into a joke. He might often be seen talking to the Makololo he had brought down from the country of Sekeletu, and their attention and respect, as they listened or replied to him, plainly showed the influence he had with them. Indeed, one of Livingstone's strongest points, and one that has conduced, no doubt, as much to his safety as his success, is his power of understanding and dealing with the natives, and of winning their confidence, while he overawes their truculence.

As regards the practical objects with which it started, this expedition fell short of success. Little was done beyond laying down the position of the comparatively unimportant lakes of Shirwah and Nyassa, and a complete survey of the Shiré and lower parts of the Zambési. Several circumstances combined to bring about this result. Though the natives of the Shiré country were found to grow very little cotton, and that, moreover, of an inferior quality, there can be no doubt that the soil is cotton-producing, and that, with proper attention, and the introduction of the better sorts of the plant, its cultivation would be remunerative. The land will grow sugar-cane, cereals on the upland plateaux—the wheat near Tette is exceptionally fine—the tropical fruits that are known, and some that are not. Indigo grows wild. The forests contain valuable woods, such as ebony and lignum-vitæ, and large-sized timber of different kinds. The rocks are metalliferous; plumbago and hematite abound; gold is not far off; and the quartz shows traces of amethyst and garnet. And something might be said about ivory. All these advantages, however, were supposed, as accounts one by one reached England, to be counterbalanced by the difficulties presented by the nature of the country, the roughness of the upland tracts, the shallowness of the rivers, and the formidable bars of the Zambési mouths.

But other things were adverse. A tribal war, which was raging on the Shiré, and a drought of unusual length and severity, threw insuperable obstacles in the way of the expedition, causing a famine in the higher country, and a disastrous loss of time in the journeys to the coast, which were rendered necessary to procure provisions. The same causes compelled the mission—after the death of Bishop Mackenzie and one of his followers—to abandon the position they had taken on the hills, and find a temporary abode on the banks of the Shiré. The hope that it would either develop into, or, at least, promote the establishment of a central trading station or factory, was in this way disappointed for the present. The subsequent death of three more of the missionaries, besides two of the expedition and Mrs. Livingstone—added to the illness from which most in the country suffered—gave to it a character for malignancy of climate which might apply to the valley regions, but not to the highlands. All these things, as they were

looked at, in England, from different points of view, led to the impression that the pictures on the Zambési had been too highly colored, and public interest flagged.

But it was not duly considered, perhaps it was never thoroughly understood, that the jealousy and secret opposition of the Portuguese colonists contributed largely to Livingstone's want of success. It was to their interest to encourage the upper slave-trade with all its demoralizing influences; and dispatches from the home government, in favor of the expedition, if ever received, if ever sincerely written, would be of small avail: the distance from Europe was fatal; and then the colony consisted chiefly of political refugees and convicts. Livingstone's aim was to abolish the slave-trade; and, as long as they felt that, the Portuguese on the Zambési, themselves prospering, would do all they could to throw moral obstacles in his way. They would simply not coöperate; the better disposed would sit still with their slaves around them; the less scrupulous would combine to misrepresent the country, cry down the people, and talk as loudly as possible of the hopelessness of the inland trade. Their slave-drivers all the while might be putting their gangs into the fork-stick shackles; but get rid of Livingstone and the English, and who would be the wiser?

However, things were just beginning to look brighter. A new steamer, sent out by Livingstone's friends, for the navigation of the Upper Shiré, had been taken to the foot of the Murchison Falls. Several miles of broken country divide the Upper from the Lower Valley, over which the steamer, built accordingly, was to be carried piecemeal; a road had been already commenced for the purpose, when Mackenzie's successor arrived from England, in the middle of June, 1863, bringing the dispatch from Lord John Russell, recalling the expedition. This, in connection with other ostensible grounds, induced Bishop Tozer to remove the mission to another sphere of work; and, in the summer of 1864, the original members who survived were once more in England, Dr. Livingstone himself following in the autumn.

And now commences what is likely to prove the most eventful period of this remarkable life. It would seem that the independent spirit which chafed under control at the outset, could find a stimulus only in roaming over its congenial wilds, and must be left to work out its grand problems at its own unfettered will. For in the autumn of 1865 Dr. Livingstone is again on his way out to Eastern Africa, unsupported by public aid, and entirely alone, crossing first to Bombay. His object was—the words are Sir Roderick Murchison's, in 1867—"to discover whether there was an outlet to the south from Lake Tanganyika, discovered by Burton and Speke, which was a fresh-water lake, and which, but for such an outlet as was supposed, ought to be a saline lake." The Rovuma River, between latitude 10° and 11° S., had previously engaged his attention, and he thought by ascending this to be able to connect it with Lake Nyassa, in which case, having no

mouth bar, and lying beyond Portuguese territory, it would afford a better entrance to the Shiré country than the Zambési. Starting from Zanzibar, he found no connection to exist between the Rovuma and Lake Nyassa, and, from a thorough examination of its north end, that there was no communication between that lake and Tanganyika. Livingstone's idea has been mentioned, on first hearing of these lakes in the interior, that, on the supposition of a central dividing line, between the north and south river systems, the region about them would be found to be the water-shed of the Nile. This theory it seems to have been his object now to establish, by tracing, if he could, a northern outflow from Tanganyika into Sir S. Baker's great lake, the Albert Nyanza. "Go," said Sir Roderick, even before he left England, "and you will then be the real discoverer of the sources of the Nile!"

Soon after starting toward Tanganyika, a little to the west of Nyassa, the men he had engaged at Johanna were frightened by a report of native ferocity, and, deserting him in a body, returned to the coast with the story that he had been murdered. The story ran, that in marching westward from the north end of the lake, the party was attacked by a body of Mazitu—a Kaffre tribe, who are known to have emigrated from the south side of the Zambési. The Johanna men were some distance behind with unloaded guns, and saw three men attack the doctor, who had fired, and was trying to reload. One struck him behind the head with an axe; he gave a loud cry and fell dead. Two of the Mazitu were found lying near him, shot with his revolver, and the bodies of some boys he had brought with him from Bombay. The Johannese hid in the bush till the Mazitu had retreated, and then, having buried their master, travelling by night made the best of their way back to Zanzibar.

The murder was said to have taken place in August, 1866, and the details were circumstantial. In July, 1867, an expedition left the mouth of the Zambési, dispatched by the Royal Geographical Society, under the leadership of Mr. Young, formerly master of the Pioneer, with a view of obtaining some clew to Livingstone's fate. The voyage to Nyassa and back was accomplished in a little steel boat which could be taken to pieces, and on November 11th they were once more at the Zambési mouth. On his return to England, Mr. Young gave his report. He had ascertained the route taken by Livingstone in crossing Lake Nyassa, and had been able to trace him to the village of a chief, Marenga, at least five days' journey beyond the point of the reported murder! The chief was an old friend of Livingstone's, and assured Mr. Young that, if the doctor had been killed one month's journey beyond his village, he, Marenga, must have heard of it. Mazitu had never been seen in that part of the country; and the story of the Johanna men was a gross fabrication to cover their own cowardice!

A letter from Livingstone himself, dated February, 1867, and received many months later, confirmed the facts brought out by Young: but, after the arrival of that, nothing but vague and unreliable rumors reached England. We were again left in doubt as to the fate of the intrepid traveller. At last tidings came. A letter appeared in the *Times* of December 13, 1869, written by Dr. Livingstone to Dr. Kirk, at Zanzibar, and dated Ujiji, 30th May, 1869. After referring to the untrustworthiness of the Arab traders, both in taking charge of goods and carrying letters—which accounts, by-the-way, for his long silences—the doctor writes as follows:

"As to the work to be done by me, it is only to connect the sources which I have discovered from 500 to 700 miles south of Speke and Baker's, with their Nile. The volume of water which flows north from latitude 12° south is so large, I suspect that I have been working at the sources of the Congo as well as those of the Nile. I have to go down the eastern line of drainage to Baker's turning-point. Tanganyika, Nj-ige Chowambe (Baker's?), are one water, and the head of it is 300 miles south of this. The western and central lines of drainage converge into an unvisited lake west or south of this. The outflow of this, whether to Congo or Nile, I have to ascertain. The people of this, called Manyema, are cannibals, if Arabs speak truly. I may have to go there first, and down to Tanganyika, if I come out uneaten and find my new squad from Zanzibar. I earnestly hope that you will do what you can to help me with the goods and men."

This letter refers to his discoveries east and west of the southern extremity of Tanganyika, and the unvisited lake is Kamolondo. Comparing this with Livingstone's account of his earlier explorations, in recent letters which have reached us, it helps, it would seem, to establish their authenticity, regarding which some are skeptical.

Then we were startled by the following:

"*To the Editor of the Times, February* 2, 1870:

"Sir: The enclosed letter from my son-in-law, Captain the Hon. Ernest Cochrane, commanding H. M. S. Petrel on the west coast of Africa, is at your service. It gives an account of the awful death which has terminated Livingstone's career. Your obedient servant, Richard Doherty.

"Red Castle, County of Donegal, *January* 31*st*."

"My Dear Sir: A few lines to tell you Dr. Livingstone has been killed and burnt by the natives ninety days' journey from the Congo. He passed through a native town and was three days on his journey when the king of the town died. The natives declared Livingstone had bewitched him, sent after him and told him he had witched their king, and he must die. They then killed him and burnt him. This news comes by a Portuguese trader travelling that way. Livingstone was on the lakes at the head of the Congo, making his way to the Congo, where he was going to come out. I believe this news to be true."

And so might others, if on consideration they could have persuaded themselves that, after hearing some native rumor, the thoughts in the Portuguese informant's mind had been unconnected with his wish! But time passes; and then we learn how a solitary American most

gallantly does that which three Englishmen were going to do—and not doing, did less than might still have been done—and comes home and tells the thrilling tale when and where he found the great Livingstone, and in his sore need helped him.

Mr. Stanley's story is so well known that a brief outline of the work he found accomplished after the meeting at Ujiji, November 3, 1871, will be sufficient to complete this sketch.

Leaving the renegade Johannese to carry home their lie, Livingstone first crosses the Chambézi River in latitude 11° S., which, relying on Portuguese information, he passed unnoticed as the head of his own Zambêsi, but which afterward was to prove such a name of note. In the beginning of 1867, he enters Londa, where he is kindly received by the chief Cazembe, and enters upon the exploration of the regions to the east. Lake Liemba, first visited, he ascertains to be the southern extension of Lake Tanganyika, which covers a latitudinal area of 360 miles. After many and complicated wanderings among the waters of this vast region, he reaches Ujiji in the March of 1869, and it was then the letter was written which has been quoted. Crossing Tanganyika in the following June, he reaches Ugupha on its western side, and, entering Rua (Speke's Ururoa), commences a long series of journeys of which the details are yet his own secret.

But a bird's-eye view is given us. First, a vast water-shed between latitude 10° and 12° S., a tree-covered belt, some 700 miles from east to west. From a plain 4,000 to 5,000 feet above the level of the sea, mountains rise to a height of from 6,000 to 7,000 feet, taking the same level. Countless brooks on this wide upland converge and form broad streams that flow toward the centre of a far-extending trough, which Livingstone supposes to be the valley of the Nile. Three large rivers form primary sources in this great valley; and these unite in what he calls "an enormous lacustrine river." This is the Lualaba—"Webb's Lualaba," as he names it, after his friend, the owner of Newstead, to distinguish it from other streams bearing the same appellation. In the valley are five considerable lakes. First, Bemba, or Bangweolo, into which the Chambézi flows—the most conspicuous among many other river-sources. Out of Bangweolo runs the Luapula, to enter the beautiful lake Moero, from which a stream, "Webb's Lualaba," pours impetuously through a rift in the surrounding mountains, and, spreading out in the plain-country beyond, winds away in a course of confusing tortuousness, till it enters Lake Kamolondo. The Lufira, the second of the three great primary rivers, discharges itself into the Lualaba, north of Kamolondo. Then comes the third, the Lomami, which, flowing from a lake westward of Kamolondo—"Lake Lincoln," as Livingstone styles it—fed by another Lualaba, joins the central drainage-line lower down. The three thus uniting, a mighty stream flows northward toward a lake, which may be that discovered by an Italian explorer, Paggia, but which Livingstone designates as the "Unknown Lake;" for at this

point his researches are brought to a stop by the mutiny of his men, and, in a state of mind bordering on despair, and utterly destitute, he wanders back to Ujiji, leaving about 180 miles of country unexplored—the casket containing the crown of his discoveries.

When he first began the journeys which led to them from Lake Moero, he could learn nothing from natives about the central line of drainage, after leaving that lake. It might pass eastward into Tanganyika; and if so, and Tanganyika was found to be connected with the Albert Nyanza, then the Chambézi would be the farthest source of the Nile to the south; but, in this case, the configuration of the country showed that it would have to run up-hill. Or it might flow westward, and be found to be none other than the source of the Congo or Niger. To throw light on this point, Manyuema, or, as the Arabs called it, Manyema, a splendid country, but little known, and whose inhabitants were reported to be cannibals, though Livingstone rather ridicules the idea, had to be visited. Then followed the discovery of Lake Kamolondo, the southern end, in lat. 6° 30′ S., and the great central drain of the Lualaba. But, then, what of the Kamolondo outflow? Here Livingstone is left to himself; the natives know—can tell him nothing; his chronometers are defective, and he cannot depend on his reckonings; but he traces the northeast set of the Lufira and Lomami, and sees that the western, like the eastern boundary of the great valley, is elevated. He observes, too, that the central line of the Lualaba maintains a steady though sinuous northward flow; hence, he is led to the conclusion that this river and lake system has nothing to do with the Congo, but that his tedious wanderings have been to and fro among the head-waters of the Nile.

In the mean time, the question is, and will be, keenly debated. The River Kasai, Livingstone's old friend on the Loando journey, flowing into the Congo, bears another name, Loke, among the natives, and is said by them to wind out of a "Nyanja," or lake. The Lomami, according to Livingstone, is also called the "Loeki." Does this similarity of name warrant the conclusion that the Kasai is only a prolongation of the river, with its source in the Manyema country? The Kasai, with the Quango and Lubilash—the two former rising west of the water-shed in the latitude of Lake Bangweolo—were always presumed, on Portuguese authority, to be the sources of the great western river. Can the Lualaba—proved to be connected with the Loeki or Lomami—take a westward course after its prolonged northing, and, overthrowing Livingstone's assumption, become the Congo feeder? If not, another question arises: What is the course of the Lualaba after leaving the Unknown Lake? Do these great waters find a channel to the eastward, and empty themselves into the Albert Nyanza? If, according to Sir S. Baker's observations, the elevation of that lake is 2,700 feet, the lower level of Kamolondo, which is 2,000 feet above the sea, must necessarily preclude that.

But, further, if unconnected with the eastern branch of the White Nile, of which the Albert Nyanza and the Victoria Nyanza are the feeders, does the Lualaba join the eastern branch either as the upper waters of Petherick's Bahr-el-Ghazel, or as one of its tributary streams? Against the first supposition it is urged that the source of this branch was discovered by the German traveller, Schweinfurth, 5° north of the equator. But it is maintained, in favor of the second, that the Uelle, a large feeder of the Bahr-el-Ghazel, was crossed by the same traveller, which, though certainly, where he saw it, flowing from east to west, was never traced to its source. He supposed it to rise in lat. 2° N., in the range of mountains west of the Albert Nyanza; but it is uncertain. The course of the Uelle may wind in such a manner as to account for the westward setting where Schweinfurth found it. Whether a greater difficulty exists in the fact that the two rivers lie at the same altitude of 2,000 feet, yet awaits the test of accurate observation. In the mean time, it is thought that the Lualaba may prove to be connected with the Uelle tributary, and thus enter the Nile by its western branch.

But even then the old mystery will not be solved. The Chambézi is not to monopolize the glory of giving rise to the great Egyptian river. Dr. Livingstone does not think so. On the 700th mile of the water-shed, are the fountains of the two rivers, Kafue and Lecambye, running south into the Zambési. Near the same spot, the Lufira and Lomami (Lualaba) are said to have their source, flowing, as was seen, to the north. In the stoneless mound, or ant-hill according to some, on which these four fountains are reported to gush out, Livingstone is reminded of the information supplied to Ptolemy by ancient explorers, and of the description of the Nile sources given to Herodotus at Sais in Egypt. Will he be able, as he believes, to substantiate this record of antiquity, and in establishing his own theory of a dividing ridge-line between north and south—where Lake Dilolo (lat. 11° 32′ 1″ S.) may again have to be considered—find, after all, that, instead of a discovery, his labors may simply result in a rediscovery? And then as to Tanganyika and the Albert Nyanza. Dr. Livingstone and Stanley together proved that the first lake has no outlet at its northern end, and that the Rusizi—a river with eighteen tributaries, coming from the small lake Kivo—is an inflowing stream, and not a drain. What will be done in this direction? What may be the result of discovering some other outlet from a lake extending over 360 miles of latitude, and this, too, when the Albert Nyanza to the south shall be no longer, as at present, unexplored?

For the solution of these questions, we must await the return of Dr. Livingstone himself, who is, by this time, we hope, once more among the waters of Rua and Manyema, with ample stores, and well attended. In two years, though probably more, he may be able to give us his own account. But, in prosecuting the researches, whose

successful issue will leave him, in the words of his late friend Sir Roderick Murchison, "the most glorious of all explorers in African geography," it is not to be forgotten that he has other, and what must be admitted to be nobler, aims. With his never-relinquished idea of establishing a central trading-mart, and purging Africa from its slave-trade, whether Portuguese or Arab, he exhibits the old steadiness in completing a self-set task, the same tenacity of purpose. He is certainly endeavoring to end as he thought good to begin: "It is better to lessen human woe than to discover the sources of the Nile."—*Fraser's Magazine.*

ARTS IN THE STONE AGE.[1]

WHEN Shakespeare represented his philosophical Duke as finding "sermons in stones," and "books in the running brooks," he was but unconsciously exhibiting the prophetic faculty which has been attributed to all true poets. He could hardly have foreseen that his pretty yet fanciful conceit would one day be found to be sober earnest. But so it is; we have here a goodly volume of more than six hundred pages, illustrated by nearly as many excellent woodcuts, discoursing learnedly of nothing save stones and streams, and finding in them sermons of great and, to many readers, novel interest.

It might have been supposed, when Mr. Evans had published his well-known work on "The Coins of the Ancient Britons," that he had gone back as far as possible in the history of our land and nation; but, in archæological as in other sciences, there is in the lowest known depth one lower still remaining to be fathomed; every chamber opened to the light discloses others lying beyond it. From a people who had no literature, or none of which they have left any trace beyond the rude characters inscribed on their rude coins, we are now carried back to tribes and races which possessed neither coins nor letters; people who have left us neither their sepulchres nor their ashes, nor indeed any trace of their existence, save the rude triangular or subtriangular fragments of worked stone which served them for tools or weapons; and even these are usually found buried beneath the wreck and ruin, it may be, of continents or islands which have long since been worn and wasted away.

The publication of this work is remarkable as an evidence of the quickened pace which characterizes scientific research in our days. Paleontology and geology, vigorous and flourishing as they are, are still hardly "out of their 'teens;" but prehistoric archæology has

[1] "The Ancient Stone Implements, Weapons, and Ornaments of Great Britain." By John Evans, F. R. S., F. S. A. (New York: D. Appleton & Co., 1872.)

made comparatively more rapid progress than either. Not more than fourteen years have passed since the discoveries made by Boucher de Perthes of flint implements in the gravel-beds of Abbeville and Amiens, although at that time discredited and disparaged by the geol-

FIG. 1.—Polished Celts, Santon Downham, Suffolk.

ogists of his own country, were confirmed and supplemented by Mr. Prestwich and Mr. Evans. Previously to that time these objects had attracted but little notice; the things were "neither rich nor rare;" men looked at them and wondered, and then forgot them, just as before William Smith's time they gazed with a profitless curiosity on

fossil shells and bones, and thought with Dr. Martin Lister, that they might be "the efforts of some plastic power, in the earth, being the regular workings of Nature, whereby she sometimes seems to sport and play, and make little flourishes and imitations of things, to set off and embellish her more useful structures."

FIG. 2.—Hatchet from the Solway Moss.

But, since the discoveries in the Somme Valley were recognized, a flood of light has been shed upon the subject. These dry bones live, and these rude stones are found to be useful, indeed indispensable, materials for building up the earliest history of the human race. The *savants* of every country in Europe have hastened to take part in an inquiry so novel and so interesting; many volumes of memoirs have been written; our French neighbors, with their usual vivacity, have

FIG. 3.—Axe-Hammer, Thames, London.

established a journal devoted to prehistoric archæology, as well as an annual *Congrès;* and these researches having been for several years conducted by so many able and eager observers, we need not wonder that Mr. Evans, having studied the whole bibliography of the subject, both ancient and modern, and explored every considerable museum or collection, is now enabled to produce this encyclopædia of the new-born science, which for want of a better word may, perhaps, be called petrology or petro-tomology. He has introduced us into the workshops and armories of our most remote predecessors, it may be of our ancestors, as they existed not at any particular epoch, but in

all probability through a long succession of ages; and he has shown us so clearly what were their weapons and tools, of which any vestiges remain, and how they were made and used; and has correlated them so accurately, as far as might be, with similar objects found in all quarters of the globe, as well as with those described by classical writers, or in use by modern savages, that in reading his work we know not which most to admire, the industry shown in the collection and examination of such a vast amount of material, or the skill with which the information thus obtained has been methodized and arranged. The book completely exhausts the subject, and will long continue to serve as a perfect manual for the collector, as well as furnishing most useful materials for archæologists and anthropologists.

Those who are not already somewhat versed in this science will be astonished to learn the infinite variety of uses to which the apparently stubborn and unmanageable rock called flint has been converted. We may, perhaps, doubt if in the very earliest ages it was used for purposes of warfare, and we prefer to give our progenitors the benefit of that doubt, and to believe that those were "golden ages"—times of primitive piety and peace; and that it was only for purposes of husbandry, and the chase, and domestic use, that they worked up the materials found in their plains and valleys. Thus, we find descriptions of celts, or axes for felling trees, or hewing canoes, hoes, threshing-machines—as now used in the East—or perhaps harrows, scrapers for preparing skins, arrows for birds or other "small deer," knives, gouges,

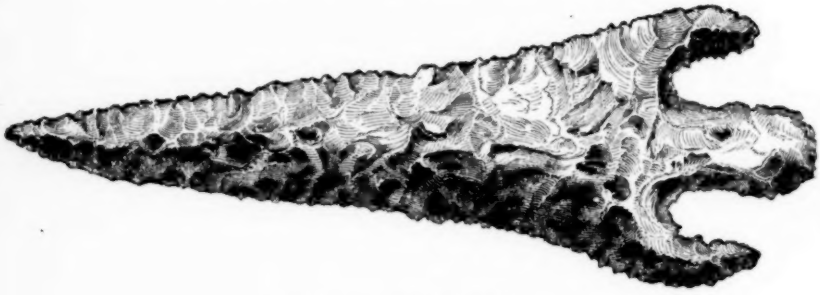


Fig. 4.—Arrow-head, Isle of Skye.

saws, mullers, or pounding-stones, chisels, hammer-axes or picks, and polishing or grinding stones, of which there must have been great need; nor were the women of the period left destitute of their share of the stony spoil; for we find in these pages descriptions and figures of rings, armlets, amulets, spindle-whorls, pestles, and, in the cave-deposits, needles of bone of admirable workmanship, which might have been, and probably were, drilled by flint-flakes.

As these primitive people have left us no record of their progress in arts and manufactures, and the material evidences bearing on the

subject are found in a very confused and dislocated condition, it is a work of no small labor to classify and arrange them in order of date, or rather of sequence, and thus none but a rough and wide scheme of classification is possible. The Danish and French authors, as well as many of our own, usually divide the stone-implement period into two principal stages only, the paleolithic and neolithic—unpolished and polished; placing them both before what has been called the Bronze age. This arrangement, however, although found convenient for popular use, and in that sense adopted by Mr. Evans, can hardly be regarded as scientifically accurate; as he has himself observed, there are blanks in the chronology of stone implements, which it is hard to fill up. The classification may be, and indeed is, too wide in one respect, and too limited in another. While, on the one hand, the drift and the cave implement periods, which are usually bracketed together as paleolithic, are characterized by very various conditions, both paleontological and geological, and, indeed, technological also—conditions which may indicate their separation by a vast interval of time; so, on the other hand, as Mr. Evans has shown at the close of the fourth chapter, some of the unpolished stones, chipped or rough-hewn celts, were probably of a date not earlier than some that were ground and polished; and, in Great Britain, at least, there are not wanting indications that the use of bronze was coeval with the polished-stone period, if not, indeed, with one or two exceptions (which were probably imports) anterior to it.

One of the most perplexing questions suggested by the discovery of the drift-implements relates to the means by which they came into their present position. They are often met with at a depth of twenty or even thirty feet, usually at or near the base of thick beds of coarse flint-gravel, which in its turn is overlain by masses, more or less thick, of brick-earth or loess. Occasionally, and indeed not rarely, they occur entirely beneath the gravels, and on the surface of the subjacent rock, whatever it may chance to be. Mr. Evans deals with them merely as constituent portions of the beds of sand, gravel, and clay, in which they occur, and so indeed they now are, but they are something more. Although of the drift, drifty, each has its own separate history; for each has been held and fashioned by hands guided by an intelligent will, and thus we are led irresistibly to inquire when, and why, and how did they come where we now see them, and why are they never found on the surface, nor under any other conditions?

To a certain extent this inquiry is involved in the far larger question of the forces by means of which the superficial gravels, of which the implements are as it were but the accidents, became dispersed—a subject which does not necessarily come within the scope of a work designed to be technological rather than geological. Mr. Evans has, however, very judiciously devoted one of his chapters to it; and, as it is one of great interest, and is still involved in much obscurity, we

may gladly welcome any attempt to deal with it, especially by one who has given so much attention to its investigation.

It was the opinion of the late Dr. Buckland, an opinion which was concurred in by Greenough, Conybeare, and other able writers of their time, that the general dispersion of gravel, sand, and loam, over hills and elevated plains, as well as valleys, was the result of a universal deluge, which is described as transient, simultaneous, and of a date not very remote; that the existing system of valleys was mainly due to the same cause, and that thus both valleys and gravels preceded our present river systems. Cuvier, and the French geologists generally, have held the same opinion, but of late years it seems to have been altogether discredited by English authors, with perhaps the exception of the late Sir Roderick Murchison. We may well entertain doubts as to the occurrence of a deluge that should be both universal and simultaneous; and it is probable that it is chiefly on that account that Dr. Buckland's theory has met with so little favor. Still, although we may be unable to adopt his views in their entirety, his statements, as to the diluvial characters of the English drifts, seem entitled to some further consideration before they are set aside altogether, and on this account it is fortunate that the recent discoveries of flint implements have excited so much interest in the gravels in question, as to induce Mr. Evans to devote no inconsiderable portion of his work to the history and antiquity of the river-drift.

In the last chapter he has adduced an elaborate argument in favor of the belief in fluviatile transport as opposed to diluvial, by showing first, hypothetically, the possibility that "deposits now occupying the summits of hills have originally been formed in and about river-beds," and then, by reference to the actual phenomena, the probability that the implement-bearing beds were thus formed. No one can doubt, upon the hypothesis here stated, that rivers may have possessed at one time a far greater power of excavating and deepening their channels than now; but then the author is obliged to assume the prevalence of several conditions, and notably a far more rigorous climate, and a greater amount of rainfall; conditions as to which we have but little evidence, and some of that is of a doubtful tendency. If, as is now supposed, the hippopotamus and elephant and rhinoceros remained here all the winter, they would have fared but badly, had the climate been as severe as is supposed.

But passing by these topics as not bearing very immediately upon the question of transport, it cannot be doubted that submergence, by means of diluvial action, is quite possible, since we have many instances of it within the historical period, and some indeed within the last few years; and, both modes of transport being alike possible, the probabilities of the case have alone to be considered; and, notwithstanding the various reasons so ably stated by Mr. Evans, it does not seem that there are sufficient grounds for rejecting Dr. Buckland's

theory, and there are, besides, some inferences to be drawn from the position of the implements, which, so far as they are concerned, are at variance with the theory of fluviatile transport. For instance, when met with in valleys, it appears that the implements are not found along the whole course of those valleys, as well where flint-gravels are wanting as where they abound, as would have been the case had they been carried down promiscuously by the streams from time to time; but, only in certain limited areas, and then usually in large numbers, and at about the same levels; and further, that in several of these deposits the implements are distinguished from those of neighboring deposits by some slight difference in form. From these indications it may be inferred that they were made and left at or near the spots on which they were found, and afterward covered up, and occasionally displaced, by the masses of drifted material which now overlie them; and this seems the more probable, when it is seen that some of them were formed from stones of the same kind as those composing the beds in which they rest, and that some of these appear to have lain exposed upon the surface for long periods before they were worked.

Fig. 5.—Sling-Stone, from Aberdeenshire.

If, indeed, it had happened that these things had never been found elsewhere than in river-valleys, the conclusions arrived at by Mr. Evans would have been irresistible, but, so far from this being the case, it is certain that these implement-bearing gravels are occasionally found on the extreme margin of sea-cliffs, or isolated hills on the verge of far-stretching plains—situations to which no river flowing in the same channels, and draining the same areas as now, could have carried them.

Mr. Evans has noticed several of these deposits as met with at Bournemouth, the Reculvers and the Foreland cliffs in the Isle of Wight (to these probably should be added Southampton and Brandon Down, and some others); and he has also alluded to the remarkable

discovery, in the Madras Presidency, of implements of quartzite of true drift-type, found on the cliffs at an elevation of 300 feet above the sea, in a bed of ferruginous clay, which forms the coast-line for several hundred miles, and is intersected at right angles, at various intervals, by the rivers of the country in making their way to the sea.

In all these cases, all traces of the ancient rivers, if indeed they ever existed, have been entirely effaced; neither channels, nor outlets, nor adequate water-sheds, nor a single land or river shell, remaining to testify of them; and not only so, but we find many deposits of quaternary gravel (which Mr. Evans justly concludes to be of the same geological period as those of the implements, and to owe their existence and position to the same causes) on hills which could not have been reached by modern rivers. The whole country would have been a vast lake before such heights could have been submerged; and under such circumstances it may be fairly assumed that the same forces, whatever they were, that covered the hill-tops, may have partially filled up the valleys; the presence of gravel may suggest, but cannot prove, that the river brought it, however much it may have rearranged and sorted it; both valley and gravel may have had an existence before the river began its course. We have many valleys and gravels without rivers, and rivers without gravels; they can very well exist apart, and doubtless have often done so.

Fig. 6.—Spindle-Whorl, from Holyhead.

One of the arguments usually relied upon, in support of the belief in fluviatile, as opposed to diluvial, agency in the formation of the deposits in which the stone implements are found, is founded on the assumption that the constituents of these quaternary gravels are petrologically such, and only such, as belong to existing river-basins; and this fact, Mr. Evans says, holds good in France and England, and cannot be too often reiterated. Without pausing to consider how far this argument might avail as against those who, like Dr. Buckland, believe in a simultaneous and universal cataclysm, it seems hardly applicable

to the conditions under which the implement-bearing drifts are found; for if the term petrological is to be understood as meaning rocks found *in situ* in the river-basins, and thus native to the soil, then it is not the fact that the constituents of the gravels in question belong to those basins; for we know that they are often largely made up—in one instance cited by Mr. Evans, to the extent of 50 per cent.—of the quartzose stones known as Lickey pebbles, and rounded fragments of jasper, quartz, and other foreign rocks. Such rocks certainly do not belong petrologically, in the proper sense of that term, to the river-basins in which they occur, but to strata of a far earlier date. As Dr. Buckland has shown, the quartzite pebbles are derived from the New Red sandstone beds in Warwickshire and Leicestershire, and were at some remote period forced over the escarpment of the Oolite into the south and east of England. Whether they were brought in before or after the present river-valleys were formed is not very clear, nor perhaps very material. It is incontestable that they were transported from a great distance, and possibly by the same forces that brought the flint-gravels; and it is equally certain, in several instances, that their transport cannot be attributed to rivers now in action, because those rivers flow, as at Brandon, toward the quarter from which the stones were brought.

Nor, if it were certain that the intrusion of these rocks dated back to the Glacial epoch, as is usually supposed, or to some other very distant period, and had thus become denizens, if not natives of the soil, could the inference which is drawn from the absence of extraneous rocks be regarded as satisfactory.

The occurrence of alternate elevations and depressions of the land above or below the sea-level, during the post-glacial times, has been suggested by several English writers; and, if we suppose a district comprising the south of England and the north of France, corresponding, or nearly so, with that in which no bowlder-clay is found, to be sufficiently depressed, and then invaded by a deluge, the argument drawn from petrological conditions will cease to apply; for, no rocks are found in the drift-gravels, but such as belong to the supposed deluge-basin. A deluge of short duration would not necessarily introduce any foreign rocks into the submerged area, but would sweep into hollows and valleys those that came in its way; and, even should the submergence be of long continuance, as in some provinces of Holland, it would leave no more traces than those exhibited in our drift-gravels. That such a partial deluge was both possible and probable is evident, when it is considered that a depression of 600 feet would perfectly well effect it; and, as we have evidence that the land has risen in several places 30 feet and more within the historical period, it is not difficult to believe that, in the infinitely longer time that probably intervened after the Glacial epoch, the same process of elevation may have been going on for many ages.

The absence of all traces of a marine fauna, and the occasional presence of land and fresh-water shells in these beds, are circumstances on which much stress is laid by the author; but, when fully considered, they hardly seem to warrant the inferences drawn from them. A marine fauna requires a marine flora for its sustenance, and, unless the submergence had been of long duration, this could not have existed. We find extensive marine deposits of older date, in which no marine organisms are ever seen; and, if marine fossils are wanting in drift-beds, those of the land and fresh water are usually equally wanting. We have, probably, hundreds of square miles of quaternary gravels, in which not a single specimen has ever been discovered. In those instances, comparatively rare, in which they occur in the implement-bearing beds, they are usually lying above the gravel, and may thus be ascribed to a later date; or, if of an earlier date in some instances, their occurrence would not of necessity exclude diluvial action, as regards the gravels.

There is one interesting topic connected with these drifts, which Mr. Evans has not dealt with at any length, as, indeed, it barely came within the design of his work; but he seems to share the general opinion that the men who made and used the drift-implements were contemporary with the hippopotamus, elephant, rhinoceros, and other animals, with whose remains they are often found associated. At present this is but a possibility, and it is an assumption founded on the fact of the bones and implements being often found in close proximity; but, if, as seems probable, the implements were formed from stones found in the gravels in which they now rest, it can hardly be doubted that the bones were already in that gravel, and may have lain there for centuries. From their shattered and way-worn condition, they have evidently been subjected to much rougher usage than that which some of the flint implements have met with. But, however this may have been, there can be no doubt, as Sir Charles Lyell has observed in the "Antiquity of Man," that "the fabrication of the implements must have preceded the reiterated degradation which resulted in the formation of the overlying beds;" a process for which vast periods must be allowed, and one which must have involved important geological changes. Among others we have very strong reasons to believe was the severance of our island from the Continent, an event, indeed, which, however brought about, could hardly have been unattended with important changes in the contour of the adjacent districts, and the courses of their rivers. When we contemplate the vast changes, geological, paleontological, and geographical, which our race seems to have survived, we are surprised to learn how very old we are, or, as Mr. Evans has better expressed it, the mind is almost lost in amazement at the vista of antiquity thus displayed.

It would seem, as might be expected, that, notwithstanding the cosmopolitan character of these objects—for, as Mr. Evans's researches

have shown, they are found in one form or other in every country on the face of the globe—certain forms are pretty well confined to certain localities, as if each of the tribes or families who used them had its own manufacture. The half-polished and polished celts of Norfolk,

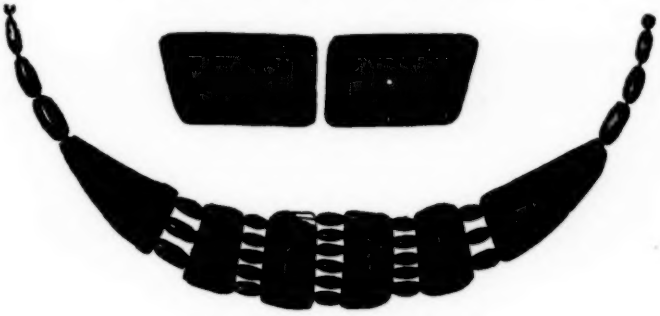


Fig. 7.—Jet Necklace, from Ross-shire.

Suffolk, and Cambridgeshire, vastly outnumber those which have been observed in all other parts of England, from which it would seem that these countries were more populous, or the people more advanced in the arts, than in the rest of the island, or possibly they may have been the manufacturing district of the period. As regards, however, the distribution of the drift-implements, a far more suggestive and important circumstance is to be noticed. As Mr. Evans has observed, the district farthest north of the Thames, in the gravels of which flint implements are at the present time known to have been found, is the basin of the river Ouse and its tributaries. They have, in fact, been found, at one time or other, in every English county lying to the southeast of a line drawn from the Severn to the Great Ouse, corresponding thus far with the great escarpment of the oolite, but they have never been met beyond that line; and it is an interesting subject of speculation to what the dearth of these objects in the country lying to the northwest is to be attributed. If it was habitable and inhabited, it is difficult to imagine a reason for their absence, especially as in Yorkshire and Lincolnshire there is abundance of suitable chalk-flint. This line of demarcation is not very much out of that which separates the bowlder-clay districts from those in which no bowlder-clay is met with. May it not have been the case that, when the implements were fashioned, Scotland and the northwestern parts of England were still submerged beneath the glacial sea, and that on their emergence the southeast became in its turn depressed?

Notwithstanding all that has been written on the subject, there seems to be still much doubt as to the uses for which some, and no inconsiderable number, of these objects were designed. For all useful purposes it would have sufficed that the cutting-edge of a celt should alone be polished and ground; yet it is often, indeed usually, found

that the entire surfaces of the faces and the sides exhibit a polish which could only have been obtained by long and apparently profitless labor. And not only so, but many of these are very fragile, being slightly made, and of delicate workmanship, and others are of such small dimensions that, as M. Boucher de Perthes pointed out, they never could have been available for any kind of hard work. Many of these exhibit no signs whatever of fracture or even of scratching, either at the butt or the edge—indications which could not possibly have been wanting, had they ever been used for weapons or tools. Besides which, while many of the districts, in which they are found, contain abundance of rocks suitable for all ordinary purposes, these implements are often made from Asiatic jade, jadeite, tremolite, serpentine, green porphyry, nephrite, and other stones of beautiful colors, and capable of taking a high polish, many of which must have been brought from great distances, and would have been very costly both to import and to work. The museums in Brittany, and particularly that at Vannes, are very rich in jadeite implements of this kind, but they are also found frequently both in England and Scotland.

FIG. 8.—Jet Armlet, from Guernsey.

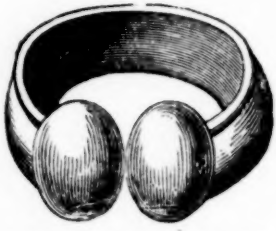


FIG. 9.—Bronze Armlet, from Guernsey.

But, if we conclude, as we must, with the author, that implements, for which such beautiful and intractable materials were selected, could hardly have been in common use, we may indulge in some speculation as to what were the uses they were designed to serve, notwithstanding that, as Mr. Evans says, we have not sufficient ground for arriving at any trustworthy conclusion. M. Boucher de Perthes thought that they were deposited by the survivors in the graves of deceased friends, as useful to them on their resurrection, and he argued from this their belief in a future state. It seems, however, hardly probable that objects, many of which obviously could not be serviceable, should be placed in tombs under the belief that they would be so at some future date. In the absence of any more satisfactory explanation, it may be suggested that these things were intended by our remote predecessors to represent the deities whom they worshipped, and that, by their varied sizes and shapes, they indicated the ranks and orders of their idols. We may believe that men, not having learned the art of representing the human or animal form, were obliged to content themselves

with symbols of their divinities—it may be their Mars and Ceres—under the form of weapons of war, or instruments of agriculture. Nor is this so unlikely as it might otherwise appear, when we know that these celts are still objects of worship in India. Mr. Evans, quoting from the Proceedings of the Asiatic Society of Bengal, says that they are there venerated as sacred, and it is known that, in a certain village in the Shewaroy hills, some hundreds of polished celts, of varying sizes, resembling those found in England and Scotland, are preserved in a temple, arranged in rows. They are guarded with the utmost jealousy by the priests, each representing some particular *swamy* or deity, and each receiving from time to time a dab of red or white paint, as a proof that the priest has performed before it the customary *poojah* or worship.

This being so, the discovery of these implements in Europe may have some bearing upon an important ethnological question. We have good reason to believe that the dolmen-builders came, in the first instance, from India, for we find in Wilts and Berks, and elsewhere, exact counterparts of some megalithic structures, and those of a peculiar construction, which yet remain in the same Shewaroy district in which the celt-worship is still practised. May we not, then, regard it as possible that the fabrication of polished instruments, as well as the practice of dolmen-building, originated in India, where they are still retained, and that these costly polished celts were brought hither by our Aryan ancestors, as the Israelites carried their Teraphim about with them, or as the Trojans, after the fall of their city, are represented in Virgil as carrying with them their household gods:

"Ilium in Italiam portans, victosque penates;"

and that the worship was only abandoned here as men became enlightened, or were subjected to the dominion of some race of a different theology? Since we find abundant traces of the Aryan language in our own, and of their sepulchral architecture in our dolmens, why should we not find in our fields and fens some of their idols? It is quite consistent with, and in a certain sense confirmatory of, such a belief, that, in almost every country in which these things are found, they are regarded by the common people with superstitious reverence, as if the practice of adoration had in the lapse of ages merged in a vague and faint tradition of sanctity.

Nor is it any objection to this hypothesis, but the reverse, that these implements are usually found in and about dolmens, as at Tumiac and Mont St. Michel, where nearly seventy highly-polished celts of imported materials—Asiatic jade and hard tremolite—were found ranged in regular order. It has been usual with almost all people, in all ages, that those things which they most esteemed in life should rest with them in their graves; and as we often find in our own country the priest's paten and chalice placed in his coffin, or the Anglo-

Saxon's sword and shield laid beside him in the earth; so, possibly, these prehistoric men may have wished that the stone idols which, when living, they adored—the lares and penates of their time—should be laid beside them in their tombs.

But, in pursuing the train of thought suggested by our author, we had wellnigh forgotten his book, and we have only space to congratulate all those who are interested in these researches—and they are now many—on the ample and valuable additions which he has made to this new and most interesting chapter in the history of our race.

CULTIVATING WILD-FLOWERS.

By Prof. SAMUEL LOCKWOOD.

BUT few are aware of the many American wild-flowers which merit and would repay cultivation. The showy scarlet sage (*Salvia coccinea*) is a common sea-coast weed in some of the extreme Southern States. In the North it has deservedly become a favorite; and culture has placed it within the reach of every one, even the poorest. The brilliant, deep-red cardinal-flower (*Lobelia cardinalis*) is highly esteemed abroad as a garden-plant; and yet, to dwellers in our cities, this plant is almost unknown, although it is one of our common wild-flowers, lavishing its bewitching beauty in numberless places, both North and South. Nor is the above word a mere figure of speech. An English scientific gardener lately visited Long Branch. He took a ride among the surroundings of that watering-place. When between Eatontown and Red Bank, he suddenly requested the driver to stop, at the same time uttering an exclamation which caused Jehu to doubt the gentleman's soundness of mind. The carriage was stopped, and away went the well-dressed Englishman over the field-fence, as lithe and agile as a youth. He actually plunged into the half-swampy ground, and made, as nearly as possible, a straight line toward a scarlet speck in the vernal distance. No high-mettled bull in a Spanish arena ever went more intently at the little red banner of the *picador* than went our friend John B., Esq., through that wet New Jersey meadow for that scarlet flower, which drew him like a fascination. It was a pitiable plight that he presented on his return to the carriage, exultant with his prize. To the astonished driver he offered these apologetic words: "This is the splendid *Lobelia cardinalis*, which I have cultivated with so much care at home, and, behold! here it grows wild!" To which Jehu, whose astonishment had now become modified by a shade of contempt, returned an ingenious equivocation: "That *is* worth a gentleman spoiling his clothes for!"

We know of more than one little cottage flower-patch, whose owner has planted in it the cardinal-flower, where it has grown in such decided prominence of beauty as to maintain a sort of pontifical preëminence among the floral dignities of the parterre. This splendid flower, with its racemes like scarlet rods, and the habit of the plant, so upright and graceful, with a sort of queenly bearing, and gorgeous magnificence, very much outshone its gayer but straggling companion, the gaudy scarlet salvia. We know a village blacksmith who thus made this plant the spectacle in his flower-plot; and it was amusing to see persons, in their admiration, seeking to purchase plants from this little garden, utterly ignorant of the fact that they could be had simply for the going after in the contiguous meadows. As a wild-flower, they had often seen it, but had never observed it. Forsooth, how few obey the æsthetic command: "*Consider* the lilies of the field, how they grow!"

And there is the common spreading dogbane, to which science has given one of its terrible sesquipedalian names, to wit, *Apocynum androsæmifolium*. It is an engaging plant, for all that, with its open, bell-shaped flowers. Its first cousin, the Indian hemp, though very unpretentious as to its flowers, has an upright habit, much more queenly than the loose *abandon* of its beautiful flowered relation. Alas! for its reputation, this plant has fallen into bad hands, and become notorious among the empirics of medicine. Speaking of the spreading dogbane, a correspondent of the Torrey Botanical Club, quoting authorities, describes it as "one of the most charming of our native plants. The beautiful clusters of rosy bells, with their pink bars, and delicate fragrance, claim for it a place in the garden, where, however, we do not meet with it, but on open banks and by the side of roads or cultivated fields. It is well approved, too, by the insect tribe, who are, in general, much more appreciative judges of color and odor than we are. In Europe, where it is not native, it is cultivated in gardens, and, according to Lamarck, is called *gobe-mouche*—fly-trap. If flies alight on this plant, they are frequently entangled by the glutinous matter, and destroyed. Hence, the plant has been called *Herbe à la puce*."

It has surprised me that so little has been done with our starworts, or native asters—plants so prodigal of bloom during the late summer, and almost the entire autumnal months. The number of species is very great, and some are of exquisite beauty. Our favorite is the *Aster concolor*. It abounds South, and comes as far North as the Pines of New Jersey, where it attains perfection in delicacy of structure and prodigality and compactness of bloom. Indeed, this part of New Jersey has seemed to us as the prodigal border-land, where the Southern and the Northern floras terminate and commingle, or overlap each other. Here Michaux and other great men have labored, and carried away many novelties. In these regions, the *Aster concolor* grows up like a simple wand, with its small leaves closely hugging the

remarkably small stem, much as if a wire had been dressed with leaves for festal uses. The upper part of the stem is so closely surrounded with the compact flowers, that it is literally a purple raceme or wand. Cultivated in mass, in a dry soil, this aster would glow like a sheet of purple flame.

And why is the very common, yet very stately, gentian overlooked? This plant is positively unique in character. A single stem set amid green leaves, with cerulean gems, is a thyrsus worthy of a god. But there is a quaint, coyish modesty about it—its singular flowers seem to be always in bud, as if too coy to blossom outright.

And what charming terrestrial orchids are found native—but, concerning this, there is but space for a word. These singular indigenous flowers—so lovely, and yet so eccentric—are represented by a large number of species. They may be called pretty, winning little oddities. They would need some skill, perhaps, in their cultivation; and some might come to be regarded as the coquettes of the floral community, jilting the gardener with futile promises. Last summer, we took up with our fingers a pretty specimen of the *Calopogon pulchellus*, which means the Beautiful Little Beard. It had but one tiny scape, growing from a green bulb which lay in the moss, much like a solitary egg in a bird's-nest. The entire plant, with its marvellous flower, was not more than six inches high. Our heart failed us in an attempt to put it in the press as a specimen; so we planted it in a little pot, attached to it a label bearing its scientific name, for popular name it had not, and then put it on the glass case on the counter of the apothecary. It was a pleasant surprise to everybody who saw it. Many were the ejaculatory commendations received by the little stranger with the purple hood, and the quaint little beard of so grotesque dyes of pink, and yellow, and white. The pretty stranger was unanimously voted "charming;" and was by some taken to be a rare exotic, that had grown up under the professor's care. Besides this, we have among our native orchids the equally pretty Pogonia and Arethusa; while, worthy of any conservatory, are the white fringed and the yellow fringed Rein-orchis, both of the genus *Habenaria*. Mention might be made of the Lady's Slipper, the showy and rather ostentatious *Cypripedium;* but the list is a long one. These native orchids are all eccentricities, and we have selected the most lovable, and the most easily attainable—in fact, those the nearest to our hands.

Just as the above was written, the usual monthly report of the Department of Agriculture came to hand. The following paragraphs are so much to the purpose, that it would be nothing less than blameworthy not to quote them. Speaking of American plants in Great Britain, it cites an English journal as saying: "The beautiful *Asclepias tuberosa* is, this season, producing freely its showy, bright orange-colored flowers in several collections round London. This fine perennial thrives perfectly well almost anywhere, if planted in sandy peat."

In the same journal we find the following: "One of the best hardy aquatic plants, in flower at the present time, is the North American Pickerel-weed (*Pontederia cordata*), a plant by no means so often met with as it deserves to be. It produces a stout spike of handsome sky-blue flowers from 1½ to 2 feet high. No ornamental water should be without this charming aquatic, which should, however, have a place near its margin." "The American Pitcher-plant (*Sarracenia purpurea*) is thriving as well as any native plant in the bog-garden in Messrs. Backhouse's nurseries at York, and by its side a healthy little specimen of the still more curious *Darlingtonia Californica* is beginning to grow freely."

The Asclepias family in America is very rich in species, but the above-mentioned one is by far the noblest of them all. From the fact that it attracts around it large numbers of these beautiful creatures, it is often called the Butterfly-weed. The plant was formerly held in high repute as a medicine, under the name of Pleurisy-root. But its gorgeously-colored flowers, so intensely orange, and so densely massed in heavy umbels, present a gorgeous richness which is incomparable. There is an African species, with flowers of a similar color, which is carefully cultivated in conservatories; but, when contrasted with our native plant, on every count, the foreigner becomes tame, and mean, if not insignificant, in the comparison. As to the Pickerel-weed, it is of easy culture; and in the margin of garden-ponds, or fountain-basins, it might be pronounced as gracefully genteel. The Pitcher-plant, if set higher up on the banks in a bed of sphagnum, or bog-moss, would be so uniquely elegant as to deserve the epithet *recherché*. This same plant can be grown in a pot, simply by keeping the saucer well supplied with water, while its quaint flowers, and the curious structure of the leaves, would make it the favorite bit of bijoutry in the floral jewels of the window.

This culture of wild-flowers, to some extent, can be indulged in by almost all. Its effect upon a mind of average intelligence is surprising. We have, in our acquaintance, a village bricklayer, a man whose means are of the most slender kind. He has a love for flowers, and shows considerable tact in producing effect by massing the different popular sorts. The imported asters, the improved petunias, and pansies, are severally made to effect a blaze of color. But his chief affection centres in a little spot where he keeps his wild-flowers, among which he pointed out to us, with an amiable pride, his pet pogonias, obtained from the swamp over the way. This man has become quite a systematist in botany, and is deservedly looked upon as the botanical light in his community. And who could possibly indulge in this pleasure of wild-flower culture long without wanting to know the names of his plants? But, as few of them have popular names, he must turn to botany for information. Thus this innocent and elevating pursuit may become a key to the acquisition of scientific knowledge, and the

application of scientific methods. Here we stop, with the sense of a child who has picked up a few spangles which have dropped from Flora's rich attire.

THE VELOCITY OF THE WILL.

By R. RADAU.

TRANSLATED BY A. R. MACDONOUGH.

IT is a common idea that the saying "as quick as thought" expresses the *ne plus ultra* of speed—an unapproachable rapidity, instantaneous and lightning-like. The phrase seems used, indeed, as an hyperbole; but in one sense, at least, this is a mistake. Thought, it is true, can transport us afar without taking note of distances, because there is no more difficulty in bringing up, in fancy, a remote object, than one that is close to us, and in this view it may be allowable to say that space creates no obstacle to thought—not impeding nor changing it in the least. But thought never springs instantaneously under the influence of an external cause; an appreciable time elapses, one or two tenths of a second, before an idea is aroused in the mind in consequence of an impression received by the brain, and before it will respond to that idea by the movement of a limb. So the nervous current which transmits sensations to the brain, and bears the commands of the will to the extremities of the body, requires a certain time to finish its course. Impressions coming to us from without are not perceived at the very instant of their production; they travel along the nerves with a speed of from 60 to 90 feet a second, equal to that of the carrier-pigeon, or the hurricane, or of a locomotive under full steam, but very much less than the swiftness of a cannon-ball. For instance, we are conscious of an injury in the feet only after a half-tenth of a second has elapsed. The commands of the will pass from the centre to the circumference with no greater rapidity; the limbs do not instantaneously obey the motive thought. When a movement is provoked by a shock received in any part whatever of the body, the stimulus at first travels as far as the brain; there a thought is developed, the will determines to send out an order; this order runs along the nerves to the limb which is bidden to act, and, at last, the limb begins movement. All this takes place in three times, of quite an appreciable duration.

In the human body, this time lost is a mere trifle, some hundredths of a second; but let us suppose one of a great cetacea, a whale, for instance, in which the telegraphic net-work of the will controls a wider range. A boat attacks it in the rear, the harpoon strikes the monster's tail. Then the pain sets out on its course to demand revenge; but the journey is long—it must travel over 90 feet before reaching the

headquarters of the will. Here is one second lost. What takes place then? How much time does reflection need? That depends on circumstances; but it is certain that the will does require a measurable time to make a decision. Then it acts; the order is sent out to the tail to thrash the boat to bits. Another second elapses before the message reaches its destination: total, two seconds gone, during which the boat and sailors get off clear by vigorous rowing.

It will be asked, How have philosophers succeeded in measuring the rapidity of the onward movement of nervous stimulus? Several methods of calculating it have been devised. A doctor of the middle ages, cited by Haller, gave some thought to it long ago. He conceived—a singular notion—that the speed of the nervous fluid might be deduced from that of the blood in the aorta; these two rates, he fancied, must be in the inverse ratio of the sizes of the aorta and the nerve-tubes. That calculation assigned, as the speed of the nervous fluid, 600,000,000,000 of yards a minute—600 times the rapidity of the motion of light.

Haller himself undertook the task in a different way. Reading the "Æneid" aloud, he counted the number of letters he could pronounce in a minute with a very rapid utterance. He found 1,500 the extreme limit, or one fifteen-hundredth part of a minute for each letter. Now the letter *r* requires, Haller says, ten successive contractions of the muscle that gives the tongue vibration, and from that, he adds, we may conclude that in one minute this muscle can contract and relax 15,000 times, which represents 30,000 simple motions. The distance from the brain to the muscle in question is a little over three inches. If the nervous fluid travels it 30,000 times, that makes more than 9,000 feet, and 9,000 feet a minute represents a speed of 154 feet in a second. This reasoning is a mere sequence of mistakes, and the approximation to the right view that Haller gained is the more astonishing because his method was not in the least likely to ascertain it. The "Æneid" justifies, in this instance, its ancient pretensions as a book of oracles.

Not until 1850 were these researches resumed by a new method that led to the solution of the problem. It is due to Helmholtz, the most famous of the German physiologists, who unites, to rare talent as an observer, the profound learning of a consummate mathematician. His first method is founded on the use of the chronoscope of Pouillet. A galvanic current of very brief duration acts at a distance on a magnetized needle, and swings it away from the normal position; the range of the deviation is measured, and the length of the current deduced thence by calculation. A means is thus gained for measuring intervals of time not exceeding a few thousandths of a second. Helmholtz applied this method in the following way: One of the muscles of a frog's leg is fixed at one extremity in a nip, and attached at the other extremity to a little lever forming part of a galvanic circuit. A

weight, hung on this lever, serves to give the muscle the required tension. Every thing is so arranged that, at the instant the current is closed, a shock is produced either directly in the muscle, or in a given point of a nerve which is isolated for a length of about an inch, and still adheres by one end to the muscle which it is to stimulate. Under the influence of this excitement, the muscle contracts, stirs the lever, and breaks the electric circuit in which it was a part. The duration of circulation of the current is indicated by the magnetized needle. It is found, then, that contraction occurs later when the nerve is excited than when the muscle is excited directly; the difference discloses the speed of transmission of the nervous agent, which is found equal to very nearly 80 feet a second. Helmholtz has ascertained, moreover, that, in every case, contraction follows the electric shock only after an interval of time equal to $\frac{1}{100}$ of a second, which he calls the time of latent stimulus. The muscular fibres do not, therefore, instantly obey the spur of electricity. Thus the waters of the sea rise under the influence of lunar attraction only after the planet is long past the meridian.

After these beautiful experiments, which revealed for the first time the knowledge of the way in which a stimulus is transmitted along the nerves, Helmholtz devised another method, permitting the analysis of the phenomenon in its minutest details. In this, also, the contraction of the muscle lifts a light lever, but the lever carries a point which leaves a white mark on a revolving cylinder covered with lamp-black. A peculiar arrangement causes the same point to mark the instant of production of the stimulus, and, from that instant to the moment of the muscular contraction, the point traces a straight line in the lamp-black. When it is afterward lifted by the tension of the muscle, it draws a curve which at once represents to sight, by its appearance, all the different phases of the movement of contraction. By this method, Helmholtz discovered that the speed of the nerve-current was a fraction over 83 feet. He proved, moreover, that the tension of the muscles gradually increases from the first moment of movement, that it reaches a maximum after about $\frac{5}{100}$ of a second, and diminishes again until the muscle returns to its natural state.

This second instrument of Helmholtz received the name of a myographe. It has been perfected or rather modified by several physiologists. The great difficulty was, to measure precisely the time corresponding to the different points of the tracing drawn by the point on the cylinder. Helmholtz communicated motion to the cylinder of his apparatus by a clock-work arrangement which pointed out to the eye the length of its revolution. For this method, the use of the diapason has been advantageously substituted. Dr. Marey, in his course of medical physiology, employed for this purpose a diapason which made 500 simple vibrations every second; those vibrations noted themselves on the cylinder alongside the curve traced by the extremity of the muscle; it was sufficient to count the number of vibrations in-

scribed parallel to a part of the tracing by the muscle, to arrive directly at the time corresponding to the tracing. Marey detected, by this method, degrees of speed in transmission varying from 30 to 61 feet.

Moreover, the nerve-current travels more slowly at low temperatures than at high ones. Dr. Munk discovered, besides, that the speed is not alike in the different parts of a nerve; in the motor nerves it seems to increase toward the point of attachment of the muscle. And, according to De Bézold, this speed decreases when the nerve is under the influence of an electric current.

The point was now to repeat these experiments on the human subject. It was found possible to conduct them in this manner: An electric current produces a slight sensation of pain on one point in the skin; the instant of action by the current is marked on the revolving cylinder of a chronoscope. As soon as the person experimented on feels the shock, he gives a signal by touching an electric key, and a second mark is produced on the same cylinder. Measuring the interval comprised between these two marks, we have the time that elapses between the two signals. This time, which is from one to two-tenths of a second, is made up of several parts; transmission of external impression to the brain, perception, reflection, transmission of the will to the fingers, muscular contraction, which is the result; but, if the stimulus is applied successively to different points on the skin, these delays are always the same, except that which is due to the transmission of sensations. If, for instance, a point on the great-toe is first excited, and afterward a point in the inguinal region, the difference in the delays remarked will represent the time employed by sensation in ascending from the foot to the middle of the body.

These experiments were first made in 1861 by Hirsch, director of the Neufchâtel Observatory, by means of an apparatus which it would take too long to describe here. The person experimented on touched an electric key with the right hand at the instant of feeling that slight pain, not unlike a pin-prick, which the knob of an induction apparatus produces on touching the skin. The knob was applied in succession to the cheek, then to the left hand, then last to the left foot. The time lost in the transmission of this stimulus from the point touched to the right hand was found equal, in the three cases respectively, to $\frac{11}{100}$, $\frac{14}{100}$, and $\frac{17}{100}$ of a second; it required, therefore, $\frac{3}{100}$ of a second for sensation to arrive from the left hand at the head, and $\frac{6}{100}$ for its passage from the foot to the head. Hirsch inferred from this that the nerve-current travels over a distance of six feet and a fraction in $\frac{6}{100}$ of a second, or about 104 feet in a second. Dr. Schelske repeated these experiments in a more thorough way at the Utrecht Observatory. He arrived at 91 feet as the speed of transmission of sensation in the human body. The same experimenter proved that the passage takes place with the same rapidity in the spinal marrow as in the nerves. This result is the more remarkable, as the nerve-

weight, hung on this lever, serves to give the muscle the required tension. Every thing is so arranged that, at the instant the current is closed, a shock is produced either directly in the muscle, or in a given point of a nerve which is isolated for a length of about an inch, and still adheres by one end to the muscle which it is to stimulate. Under the influence of this excitement, the muscle contracts, stirs the lever, and breaks the electric circuit in which it was a part. The duration of circulation of the current is indicated by the magnetized needle. It is found, then, that contraction occurs later when the nerve is excited than when the muscle is excited directly; the difference discloses the speed of transmission of the nervous agent, which is found equal to very nearly 80 feet a second. Helmholtz has ascertained, moreover, that, in every case, contraction follows the electric shock only after an interval of time equal to $\frac{1}{100}$ of a second, which he calls the time of latent stimulus. The muscular fibres do not, therefore, instantly obey the spur of electricity. Thus the waters of the sea rise under the influence of lunar attraction only after the planet is long past the meridian.

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scribed parallel to a part of the tracing by the muscle, to arrive directly at the time corresponding to the tracing. Marey detected, by this method, degrees of speed in transmission varying from 30 to 61 feet.

Moreover, the nerve-current travels more slowly at low temperatures than at high ones. Dr. Munk discovered, besides, that the speed is not alike in the different parts of a nerve; in the motor nerves it seems to increase toward the point of attachment of the muscle. And, according to De Bézold, this speed decreases when the nerve is under the influence of an electric current.

The point was now to repeat these experiments on the human subject. It was found possible to conduct them in this manner: An electric current produces a slight sensation of pain on one point in the skin; the instant of action by the current is marked on the revolving cylinder of a chronoscope. As soon as the person experimented on feels the shock, he gives a signal by touching an electric key, and a second mark is produced on the same cylinder. Measuring the interval comprised between these two marks, we have the time that elapses between the two signals. This time, which is from one to two-tenths of a second, is made up of several parts; transmission of external impression to the brain, perception, reflection, transmission of the will to the fingers, muscular contraction, which is the result; but, if the stimulus is applied successively to different points on the skin, these delays are always the same, except that which is due to the transmission of sensations. If, for instance, a point on the great-toe is first excited, and afterward a point in the inguinal region, the difference in the delays remarked will represent the time employed by sensation in ascending from the foot to the middle of the body.

These experiments were first made in 1861 by Hirsch, director of the Neufchâtel Observatory, by means of an apparatus which it would take too long to describe here. The person experimented on touched an electric key with the right hand at the instant of feeling that slight pain, not unlike a pin-prick, which the knob of an induction apparatus produces on touching the skin. The knob was applied in succession to the cheek, then to the left hand, then last to the left foot. The time lost in the transmission of this stimulus from the point touched to the right hand was found equal, in the three cases respectively, to $\frac{11}{100}$, $\frac{14}{100}$, and $\frac{17}{100}$ of a second; it required, therefore, $\frac{3}{100}$ of a second for sensation to arrive from the left hand at the head, and $\frac{6}{100}$ for its passage from the foot to the head. Hirsch inferred from this that the nerve-current travels over a distance of six feet and a fraction in $\frac{6}{100}$ of a second, or about 104 feet in a second. Dr. Schelske repeated these experiments in a more thorough way at the Utrecht Observatory. He arrived at 91 feet as the speed of transmission of sensation in the human body. The same experimenter proved that the passage takes place with the same rapidity in the spinal marrow as in the nerves. This result is the more remarkable, as the nerve-

tubes undergo great changes at their entrance into the spinal marrow, where, according to Van Deen, they cease to be sensitive to the action of electricity, of chemical substances, mechanical injuries, etc.

It follows, from all these experiments, that the nerve-current makes its way with a speed that is relatively inconsiderable. The hand in thowing a stone parts the air with the quickness of nearly 68 feet a second, which is quite comparable with that of the nervous fluid; and the race-horse, the hare, and the leveret, move quite as rapidly. The arterial wave, which passes through 27¾ feet in a second, moves only three times more slowly.

When the sensation transmitted to the spinal marrow occasions a reflex action, that is, an involuntary movement determined by the intervention of the ganglionic cells, the reflex motion always proceeds more slowly than that produced by the direct action of the exciting current on the muscles; the retarding varies from a thirtieth to a tenth of a second. It may be inferred from this that reflex action in the spinal marrow takes twelve times longer than the transmission of a stimulus through nerves of sensation or motion.

The time employed in the brain's operations is also some tenths of a second. Dr. Jaeger measured it in the following way: The subject of the experiment was made to touch the electric key with the left hand as soon as he received an electric shock on the right side, and with the right hand when the shock came from the left side. The interval between the shock and the signal was found to be $\frac{20}{100}$ of a second when the person knew beforehand, which side the shock would come from, and $\frac{21}{100}$ when he was not forewarned; thus $\frac{1}{100}$ of a second were used in reflection. Hirsch found that at least two-tenths of a second elapse before an observer marks by signal the preception of a luminous spark or a sudden sound. In other experiments it was arranged that the observer should touch the key with the left hand for a white spark, and with the right for a red one, and he lost, in that case, from three to four-tenths of a second. Therefore reflection took from one to two-tenths of a second. Donders and Jaeger made the experiment a little differently. One pronounced some syllable, which the other repeated as soon as he heard it, while a phonontograph registered the vibrations of the word. When the syllable to be repeated was agreed on beforehand, the delay observed was two-tenths of a second; when not, it was three-tenths.

As we see, then, thought does not spring instantaneously; it is a phenomenon subject to natural laws of time and space. In different observers the time lost is not alike; one perceives, reflects, and acts, more briskly than another; it is a matter of temperament and of accidental circumstance. This explains the differences always remarked between astronomers busied in observing the same phenomenon. Two persons never saw at the same instant the passage of a star across a

thread: besides, the difference between the instants noted, or what is termed the "personal equation," of two astronomers, varies more or less according to circumstances, and may increase or diminish with time. The observer's training has a great deal to do with it, Wolf having demonstrated that, by practice, the time lost may be reduced to a minimum, with the employment of a special apparatus.

An important conclusion follows irresistibly from these experiments: it is, that the nerve-fluid is not identical with the electric fluid. Electricity darts through telegraphic wires with inconceivable rapidity, far outspeeding light, and moving 20,000,000 times faster than the nerve-agent. There exists another important difference between these two forces. Any alteration in the structure of the nerves checks the transmission of the nerve-current; crushing or partial burning is enough to interrupt its passage; once cut, they do not regain their conductive power when the separated ends are brought together again. Metallic wires, on the contrary, conduct electricity in spite of all the injuries that may be inflicted on them. Yet the well-known labors of Prof. Dubois-Reymond clearly prove that electricity plays a part of some kind in nervous phenomena. Electric currents exist naturally in nerves, and these currents are influenced and modified by the action of the nerve-currents. It may be admitted, then, that nervous phenomena are the result of a secondary action of electricity, producing certain changes, chemical or otherwise, in the nerve-substance; these manifest themselves only after the lapse of a certain time, during which the action increases in a slow and gradual manner till it becomes sensible, and produces mechanical effects. This side of the question is still enveloped in profound darkness, and we are driven to more or less plausible hypotheses. Still, we can say that a great step has been taken toward the solution of the problem of life: the experiments of which this account is given have thrown light upon its approaches, and placed the question on the ground of exact science. No doubt a long time will pass before the progress of methods of observation shall permit us to make one step nearer to the goal, and nothing authorizes the belief that we can ever fully reach it; but we may take pride in what has already been done, since the exactness of the results gained surpasses all expectation.—*Revue des Deux Mondes.*

ASTRONOMICAL AND PHYSICAL OBSERVATORIES.

IT has been said that "dirt is but matter out of place," and we may likewise take for an axiom that error is force misapplied. It cannot be complained that the age in which we live is one which demands the most careful economy of our forces of all kinds, nor are we intellectually in the position which geologists are fond of predicting for

the material world—"nearly out of our store of force." But it were wisdom in us to husband the forces we have, that we may hand down to our successors a thoroughly well-ordered system in all things. And in nothing should we be so careful and scrupulous as in our schemes of education, which affect, in a very direct way, the judgment of the generation which follows us.

Sooner or later there is created in most American colleges what is thereafter known as its astronomical observatory, and in respect to this portion of the college we are frequently called on to lament over some glaring instances of wasted force—force misapplied. One of the forms of these prevalent errors is a mania for "instruments of the largest size," which are not unfrequently bought at large cost, and used perhaps a dozen times a year to allow the senior class, and perchance a few ladies, to view such objects as Jupiter, Saturn, the moon, *perhaps* a double star, and, more unlikely yet, a nebula. Its kindred error is an immense and vague desire for the multiplication of apparatus, so that one walks amid a labyrinth of chronographs, transits, meridian circles, and equatorials, upon each of which the rust of long inaction lies. We must remember that each of these instruments represents a large outlay of money, and also an expenditure of faith in the giver of them. It is bad enough to allow so much mere capital to lie idle, but it is worse not to return to the benefactor of a college something which may be the sign of a good investment, something which shall encourage him and others to believe that their gifts are doing real, practical educational good. It is here intended to speak only of the college observatory as a *means of education*, and a distinct difference is made between the ordinary institution of this kind, and the working observatories of such colleges as Dartmouth, Harvard, the University of Michigan, and others.

It is taken for granted that the ordinarily-constituted observatory is for the purpose of teaching certain specific things and certain important methods to the average class of college pupils, and it will be the endeavor of this paper to point out a remedy for some of the abuses that undoubtedly exist in this respect.

Most certainly there are but few subjects which have a greater educational value than Astronomy. As a continuation of the most advanced mathematical course, Theoretical Astronomy is of immense importance and of endless extent. The effect of its study upon the mind is of a much higher order, most of us will agree nowadays, whatever Pythagoras might have said, than the study of even the most abstract relations of number and space. It is supplementary to these last-named subjects, which are, so to say, its raw material, which it elaborates into more complex and higher forms. But let us remember, it is the boast of Theoretical Astronomy that it is *purely* a science of the closet, dependent upon observation only for its data. Its greatest master, Laplace, thus speaks in the "Système du Monde:" "Il est très re-

marquable qu'un Astronome, sans sortir de son observatoire, en comparant seulement ses observations à l'analyse, eût pu déterminer exactement la grandeur et l'aplatissement de la terre, et sa distance au soleil et à la lune, élémens dont la connaissance a été le fruit de longs et sensibles voyages dans les deux hémisphères,"[1] etc. (6me édition, p. 232).

It is evidently not the purpose of Theoretical Astronomy, then, to train faculties other than those employed in the higher mathematical investigations, and for this purpose no observatory is strictly necessary. But Physical Astronomy, as usually taught, confines itself to Descriptive Astronomy, and for that study it is undoubtedly necessary that students should have access (and a far freer access than they usually have) to instruments. To supply this want, "instruments of the largest size" have been too frequently supplied, so that it is possible that the student may contemplate the features of the moon, or the components of a coarse double star, through a 15-inch, nay, perhaps, a 20-inch object-glass, when perhaps a 4-inch telescope of Alvan Clark's make would serve the student's and the college's purposes fully. It used to be a saying of a celebrated American astronomer that "the price of telescopes increased directly as the cubes of the diameters of their object-glasses." If no higher ratio be the true one, it is evident that in the case supposed we have force misapplied, or not applied at all. It has become almost a reproach for a college not to own an equatorial of at least eight inches clear aperture; yet only consider how much of the best work of astronomy has been done with less apertures! Sir John Herschel and Sir James South executed a long and very refined series of measures of double stars with a much smaller instrument than the ordinary college equatorial, and much of Struve's best work is recorded as done with "the smaller instruments," and so on. It is not intended to advocate the use of poor instruments, nor specially of small ones, but to point out that the means should be adjusted to the object in view, and that no waste of power should be permitted. Again, Spherical Astronomy is taught in some colleges; and, in considering this branch of the subject, we are touching on its most useful portion. In nothing is a student's habit of accuracy more trained than in astronomical observation. There are minor points to be attended to each moment, and it is not until he ceases to be a pupil that he begins to be thoroughly at ease with even the simplest instrument. He has a running commentary of reasoning to make constantly, which is of the greatest value to him. He must constantly ask himself, while using his instruments, "If I do this or that, what will happen, and why?" Now, it is presumably to forward this

[1] It is a very noteworthy fact that an astronomer, without quitting his observatory, but by merely submitting his observations to analysis, could have determined exactly the dimensions of the earth, its oblate form, and its distance from sun and moon—data which have been obtained as the fruit of long and arduous voyages in both hemispheres.

branch of Astronomy—Spherical Astronomy—that the college observatory was founded, and, if it does this in the right way, it is of great value. To do this properly, requires but a small outlay. A small equatorial of, say, four inches aperture, with circles divided to one minute, will serve to exhibit every thing of interest to the general observer, and will give a student much more opportunity for work than he can possibly find time to improve. A Pistor & Martin's portable meridian circle, two good clocks or chronometers, and, if one wishes luxury, a chronograph, will fit up a small observatory in the most complete way, and give both student and professor excellent means for observation. All this could easily be bought for the price of one of the unwieldy equatorials which lie idle in so many college-towers.

We must remember, too, that the professor of astronomy in most colleges is a busy individual. I have before me the condensed catalogues of 157 American colleges, with an aggregate number of pupils so great as 34,515, and, on running over the lists of college-officers, I find such entries as the following: "—— ——, Professor of Mechanics, Astronomy, and Engineering:" or "Professor of Mathematics, Astronomy, Physics, and Geology:" or of "Astronomy and Physiology;" or, again, of "Latin, Astronomy, and History of American Literature," and many other similar mixtures.

All this indicates that very little time is given by the average student to any proper study of the subject, and the expensive and ill-considered observatories in the country certainly show that a great deal of money and time is wasted in their construction. The writer of this article is familiar with several of such ill-proportioned sets of apparatus. In one case, the observatory contains a fair equatorial of six inches aperture, mounted on a brick arch let into the walls of its tower a few feet below the floor of the dome, which arch receives every tremor of the adjacent building, which is full of students; also a fine portable transit by Würdemann, *no clock*, and a mean solar chronometer. In another a fine clock is thrown away on a zenith telescope, which is used only as a transit, and so on.

The moral would seem to be to have few instruments, to have them of the best possible workmanship for their size, and to have no one so large and expensive as to prevent the purchase of others which are necessary.

But it is proposed further to give a few reasons why, as a means of education, the astronomical observatory might well, in ordinary cases, be superseded by the physical observatory, or at least why in most cases it would be better to divert some of the funds, which would otherwise be spent on little-used apparatus, to establishing a physical observatory, on a modest basis.

And first let us remember that, to properly educate, we must not only give knowledge, but also the power to acquire knowledge; that, although facts are of great importance, the mental grasp which will

connect isolated facts is much more valuable. Viewed in this light, the study of astronomy will be readily seen to be less efficient for training the mind than the study of physics. Physics, indeed, includes astronomy as one of its parts, but, as the termph ysics is commonly used, it denotes the science of the changes and conditions of terrestrial matter, and peculiarly of the laws relating to the various emanations of celestial bodies, heat, light, etc. The subjects here referred to are such that their study requires in the very highest degree just those faculties which it is the province of modern education to train. Physics, too, is eminently a practical science; it gives the *rationale* of what we see all around us, and is, so to say, of progressive difficulty. Its elements may be taught to the young lad, and he may go on for his life in their development. Every special method which is useful educationally, that we have referred to in astronomical study, has its analogue here.

Thermo-dynamics and optics certainly present as wide fields for pure analysis as even celestial mechanics. In the cultivation of the powers of observation, the study of physics stands preëminent; and in the physical laboratory the student has an immense advantage, for in many cases it is within his power to produce by experiment, and on a small scale and under favorable conditions, the same appearances that he observes in Nature. There is thus opened to the mind a vast field for that "scientific use of the imagination" which is so important an element in culture.

Perhaps it is more than time that the exact nature of a physical laboratory or observatory should be explained, and we are fortunate in having a succinct account of its main purpose from the hand of Prof. Henry, of the Smithsonian Institution.

Prof. Henry says (Report, 1870, p. 141) the principal object of a physical observatory is, "to investigate the nature and changes of the constitution of the heavenly bodies; to study the various emanations from these, in comparison with the results of experiments, and to record and investigate the different phenomena which are included under the name of terrestrial physics."

The study of the nature and constitution of the sun, by means of photographs, by experiments on its heat, by the spectroscope, and the comparison of these results with similar observations of the stars, is also pointed out by Prof. Henry, as among the legitimate and necessary works of such an institution as he describes. Climatology, meteorology, magnetics, and electrics, equally belong to its scope.

To completely equip such an observatory as we imagine, would require a great outlay, but, considered only in its relation to a college, an equipment becomes much more simple and less expensive. The apparatus required is simple in its nature, and but few of the single instruments are of great cost, and the true policy of a college would be to allow its laboratory to grow slowly with it, enlarging its scope

as occasion demanded. In such an observatory the student would acquire every habit of nice adjustment, delicate manipulation, accurate judgment, which would be acquired in the best astronomical observatory, and the field for the mathematical discussion of his results is simply limitless.

In another aspect, too, does the foundation of such observatories hold out important promises. It must be remembered that many of our physical constants rest unfortunately upon too uncertain a basis. The velocity of electricity and the density of the earth are examples. We have to look, then, to scientific men for the establishment of these and other facts as they truly are, and besides, for the discovery of the vast number of unknown physical laws, some of which we must believe are entirely within our reach, and but waiting continued effort to declare themselves. The laws of terrestrial magnetism, the connection of the aurora borealis with other appearances, and like subjects, seem upon the point of being elucidated. It must be remembered, too, that one astronomical observatory can do the routine work for an entire country, and that, once done, it is done forever, and that any repetition of it, however useful it may be to the person making it, is yet of no original value in the world. But the vast number of unclassified facts in the domain of physics, and the almost infinite variety of its unknown laws, will supply ample work for many more physical observatories than could possibly be established. It seems decidedly to the advantage of the student and of the college that each should have the benefit of a well-appointed physical observatory, and it is certain that the class of American gentlemen who found and sustain departments of this kind in our colleges (and it is a very large class, to our honor be it said), will find, in the establishment of such an observatory as we have advocated, the pleasure which comes from effort wisely made. They will see (as they have a most undoubted right to expect to see) the immediate usefulness and benefit of their gift, and can hardly fail to have aided in the discovery of some one of the many laws of physics which lie so close to us, almost demanding discovery.

The wisest plan for the foundation of such an observatory may be found in the form of a letter in the Smithsonian Report for 1870, already referred to, and it is as an introduction to that letter that the present paper may claim to have any value.

EDITOR'S TABLE.

OBSERVATION IN EDUCATION.

AN excellent article in the *Tribune* urges the need of more and better-educated observers to carry on the work of science. Prof. Agassiz is quoted as urging the establishment, in San Francisco, of a college for the training of skilled scientific observers. It is stated that the Signal-Service Bureau is engaged in training a large number of students in the use of instruments of observation, with a view to taking charge of signal-stations for the promotion of meteorological science. We publish an able and interesting paper on the claims of physical laboratories, in connection with institutions of learning, which shall afford the necessary opportunity of training in physical observation. Of the importance of this work the writer in the *Tribune* observes: "We think the day is coming when it will be generally recognized that careful scientific observation is the most valuable labor performed in the world." And regarding its delicacy and difficulty, he further observes:

"Of the nicety of observation which science requires, it is difficult to convey to the uninitiated any idea. A man who has never before looked through a telescope would not probably be able to see Biela's comet, upon whose vagaries hang so much speculation, if he gazed through any of the instruments by which the observations on it have been obtained. The best microscopists, in approaching the more difficult class of investigations, prepare their physical systems by fasting and rest, so that even their skilled eyesight may give a purer service. Already men are training themselves in certain specialties of observation, with reference to the few minutes of work they expect to perform, two years hence, at the transit of Venus."

Now all this is most true. Excepting that higher intellectual work by which, from the facts of observation, laws are arrived at, so that general principles can be substituted for ever-accumulating details, there is no labor performed in the world so valuable as that of careful scientific observation, and it is also true that its difficulty equals its importance.

But there is a vital consideration connected with the subject, which the writer seems to have overlooked: it is that the capacity of educated observation is just as necessary for people generally as for men of science. Facts bear the same relation to principles, in common life, that they do in the higher departments of technical science. The question is, at last, simply one of evidence: what is fact, and what is not fact? Imperfect observations vitiate reasoning, and lead to erroneous conclusions in the workshop, on the farm, in the counting-room, the church, and the legislative hall, just as much as in the laboratory or the observatory. The objects are different; the mental procedure is the same. But that which is a universal necessity should be provided for by universal means, and systematic training in observation should therefore be a recognized part of our common education. Even for purposes of the higher science, this truth is not to be neglected; for you can no more make first-class observers out of young men who first take up the business in college, than you can make first-class musicians by beginning with adults. Skill in doing the most important work in the world is not to be so cheaply and readily acquired. For the sake of science itself, training in observation should begin in childhood, and become an early mental habit. There are native aptitudes here as in all other departments of intellectual exertion; and only by beginning with the young can

we find those whose natural bent is in this direction, and who, by early preparation and life-long discipline in this difficult field, can reach that standard of perfection which science now requires, and which it will continue more and more to exact. But when we take the larger view of the value of observational training, which regards it as nothing less than bringing the general mind into right relations with Nature, art, man, and all the objects and interests around us, of which we are compelled to form judgments, the claims of special science are at once subordinated to the grander requirements of humanity. Or perhaps it would be more correct to say that science is itself to be so widened and enlarged as to take control of this fundamental work of education. Until scientific education recognizes this as its first and great task, it will assuredly fall short of its highest duty.

DEATH OF MR. GREELEY.

One of the greatest personalities of our country has just passed away. We have little to add to the strain of eulogy that has been heard in all parts of the land, concerning the life and character of the late Mr. Greeley. That he has filled a large space in public attention for the past generation, is of little moment; that he has exerted an extensive influence for good upon the American people during that long period, entitles his name to be written high in the rolls of public honor. He is to be gratefully remembered, not because of his large capacities and extensive influence, but because he used his powers in the best service of his fellowmen. He ever worked in the direction of social amelioration and public improvement. Believing in the power of ideas, the value of knowledge, and the vital need of general education, and that the progress of society is an internal constructive work of its citizens, depending upon virtue, industry, and intelligence, he established a journal dedicated to these objects, and developed it into a great and powerful institution for moulding the public mind, and elevating the public character. For thousands of families scattered all over this land, the newspaper founded by Mr. Greeley has played the part of a people's university—arousing and stimulating multitudes of the young to enter upon the work of self-improvement, or to seek instruction in academies, high-schools, or colleges. Of all this it is superfluous to speak, as its living witnesses may be everywhere met, while the public press has done full justice to the magnitude and salutary influence of Mr. Greeley's work. But, there is one point in regard to his mental character upon which a few words may not be here out of place. Mr. Greeley made the most of his opportunities of self-education. He read widely in critical literature, and attained a mastership of his own language which but few of the largest opportunities of culture have equalled. It has been customary, with many, to lament that Mr. Greeley was without the advantages of a regular collegiate course of study. But he was never much troubled by this alleged deficiency. He saw too much of the influence of our colleges in turning out waste acquisitions, unavailable faculty, and capacities unadapted to the times, to regret very deeply that he had not been exposed to the same peril. This has been often attributed to the ignorant egotism of the self-made man, but, we think, very erroneously; for Mr. Greeley did have his profound regrets at his own mental shortcomings and defective culture. He deplored the circumstances of his early life, which gave him no chance to acquire the rudiments of science. We have often heard him express deep and painful regret that there was no one to guide his childhood in the direction of observing and

studying the familiar phenomena of Nature. He keenly felt that his life had been made less enjoyable to himself and less valuable to the public for want of that early cultivation of the observing powers by natural objects, of which we have just been speaking, as the great defect of our common education. He knew nothing of science, but he never despised it, as is too common with the devotees of literature and politics, who are generally ignorant of it; and he was always strong in his condemnation of our educational system, because of its culpable neglect of scientific studies. He was emphatic in insisting that the study of natural things should be commenced in childhood, so as to maintain a place in after-development, for he saw how difficult it is, when the mind becomes engrossed with other knowledge, to give proper attention to the study of science. Mr. Greeley's love of Nature was a profound and genuine feeling, and his interest in rural affairs was very far from being an affectation. All who are familiar with the course of the *Tribune* in its early days will remember the prominence given to science in its columns—the copious illustrated reports of the lectures of Lardner and Agassiz, and the fulness and ability of its treatment of scientific agriculture. Had it not been for the all-disturbing influence of the antislavery convulsions which distracted the country for twenty years, this early policy of the *Tribune* would undoubtedly have been carried out in a systematic way, and with the most salutary public results. If Mr. Greeley did not understand science, and was therefore unable to assist in its direct development, he, nevertheless, appreciated the noble part it is to play in the world's affairs, and the great service the press can render in promoting it; and, in the card announcing his return to the editorial control of the *Tribune*, he stated that this would be among the great objects to which he proposed to dedicate the remainder of his life. It is to be hoped that the managers of that journal will share in the discernment of its founder, and, as its history is indissolubly linked with the diffusion of ideas among the American people, that they will see to it that its future shall, in this respect, be worthy of its past.

TYNDALL AND FROUDE.

In the same ship came two wise men from the East, at the urgent solicitation of our people, to instruct them by public lectures. But it turns out that there are different kinds of wisdom, and our illustrious teachers represent very diverse sorts of it. Prof. Tyndall accepts, as the problem of his life-study, the universe as it is. By the help of all that has been hitherto revealed concerning the order and harmony of Nature, he engages with the living phenomena of the world as it exists around us, and is accessible to all. To understand the present ongoings of the universe, the course and polity of Nature, and the living laws by what we are all enmeshed, is his supreme and immediate task. Not what men have thought in past times, nor what they may happen to think now, but what can be demonstrated, and what all can actually know to be true, is his great concern. Asking no man to take his bare word, he shows us facts that can be recognized, principles that can be proved, laws that can be verified, truths that can no more be resisted than the physical forces themselves. He speaks to us of the order of Nature in its latest and grandest interpretations, and with such force of proof that his crowded listeners are convinced, and assent to his utterances as one man. Multitudes in our leading cities have heard him with eager attention; but there has not been a ripple of criticism or dissent even sufficient to indicate his presence among

us. This results from the quality of the knowledge he imparts, which is science, or knowledge that can be shown to be true. It is felt that so much, at all events, is gained. So far we can all agree.

The question now arises, How far can this platform of solid and irresistible truth be widened? The discovery and organization of this certain knowledge have been the work of the past three centuries, and its further expansion is the great work of the present time. Is it to be equally the task of the future, and is science indefinitely progressive? Is law universal and ascertainable, and are we to go on creating new knowledge of this kind, and reconstructing the older knowledges, until they shall take on the form and character of science? Or, are there limits, and have we reached them? The question, as all must see, is simply one of the extent of the order of natural law, for, wherever there are method and law, there is possibility of science. Prof. Tyndall represents, first of all, our sure ground of knowledge and then its certain and safe extension.

Mr. Froude, on the other hand, represents opposite ideas and modes of thought. He deals with the past rather than the present—with human events in their variable, obscure, and uncertain course, rather than with that side of the world in which law and order can be clearly shown. He represents the debatable and unsettled in human affairs, and that which will be forever debated, and can never be settled. Hence, no sooner does he open his mouth, than dispute arises, and a hubbub of contradiction and contention has followed him whithersoever he has gone. Mr. Froude gives lessons in what he calls "history," but his teachings do not enforce assent. At this we cannot complain, for he himself believes that there is neither law, order, nor science in his chosen field of labor. He belongs to the antiquated, historical school, which was in the ascendant long before science arose, and is contented to delve in the rubbish of the past, with no guiding light from principles that science has disclosed, and which even scouts all possibility of such guidance. Mr. Froude gave a lecture upon this subject before the Royal Institution, in 1864, attacking the views of those who hold that there is such a thing as a science of history and of social polity, which, although still in an indefinite stage, is yet as certain in the future as the progress of knowledge itself. The reader, who will turn to the June number of the MONTHLY, will find a convincing refutation, by Herbert Spencer, of Mr. Froude's position; and, as the subject is just now one of public interest, we reproduce some passages from an able lecture of Mr. John Fiske, of Cambridge, upon the same subject:

"Mr. Froude begins by dogmatically denying that there is or can be such a thing as a science of history. There is something incongruous, he says, in the very connection of the two words. 'It is as if we were to talk of the color of sound, or the longitude of the rule of three.' But he carries on the thought in a way that shows plainly his reluctance to grapple fairly with the problem. In his next sentence he says: 'Where it is so difficult to make out the truth on the commonest disputed facts in matters passing under our very eyes, how can we talk of a science in things long past, which come to us only through books?' Now, to reason like this is merely to shrink from the encounter. For the question is, not whether the science is difficult, but whether it is possible. Mr. Froude sets out to show that there can be no such science, and his first bit of proof is that, if there is such a science, it must be far more difficult than any other; a position which we may contentedly grant. Let us follow him a step further. 'It often seems to me as if history were like a child's box of letters, with which we can spell any word we please. We have only to pick out such letters as we want, arrange them as we like, and say nothing about those which do not suit our purpose.' And what does all this amount to? Is this Mr. Froude's idea of

historical investigation? Why, the same thing may be done in any science. We have only to pick out all the facts on one side, and blink all the facts on the other side, to prove the veracity of every oracle, soothsayer, and clairvoyant, that ever existed, the validity of every paltry omen, the credibility of every crazy notion of alchemy or judicial astrology. In this way we may prove that the homœopathist always saves his patient, while the allopathist always kills him; or *vice versa*. And it was in this way that the phrenologists erected their pseudo-science. It is in this way that every charlatanry, as well as every incorrect or inadequate hypothesis in physical or mental science, has arisen and gained temporary recognition. Mr. Froude ought to know that, in history as in every thing else, our only road to a safe conclusion lies through the impartial examination of all relevant facts. Supposing Tycho Brahe had said to his Copernican antagonists: 'Astronomy is like a child's box of letters; if we take out what we want and let the rest go, we can spell whatever we please; I spell out the Ptolemaic theory, and will therefore abide by it;' he would have been talking much after the manner of Mr. Froude. It is true, as Mr. Froude says, that one philosopher believes in progress, a second in retrogression, and a third, like Vico, in ever-recurring cycles. But is this because the facts are undecipherable, or because the investigation is one-sided? Because Prof. Agassiz believes species to be fixed, while the majority of naturalists believe them to be transmutable, are we to infer that there is no science of biology? In such unworthy plight does Mr. Froude retreat before the problem he has encountered. He starts to show us that a science of history is as ridiculous an impossibility as a scarlet B flat or a westerly proportion, and he ends by mildly observing that history is a difficult subject, in which a series of partial examinations may bring forth contradictory conclusions!

"The next bit of inference concerns us more intimately: 'Will a time ever be when the lost secret of the foundation of Rome can be recovered by historic laws? If not, where is our science?' Just where it was before. The science of history has nothing to do with dates, except to take them, so far as they can be determined, from the hands of historical criticism. They are its data, not its conclusions. As Mr. Morley reminds us, we do not dispute the possibility of a science of meteorology, because such a science cannot tell us whether it was a dry day or a wet day at Jericho two thousand years ago. Facts like these show us that sciences dealing with phenomena, which are the products of many and complex factors, cannot hope to attain that minute precision which is attained by sciences dealing with phenomena which are the products of few and simple factors. They show that sociology cannot, like astronomy, be brought under the control of mathematical deduction. But it was not necessary for Mr. Froude to write an essay to prove that.

"But, continues Mr. Froude, 'can you imagine a science which would have *foretold* such movements as' Mohammedanism, or Christianity, or Buddhism? To the question as thus presented, we must answer, certainly not. Neither can any man foretell any such movement as the typhoid fever which six months hence is to strike him down. If the latter case does not prove that there are no physiologic laws, neither does the former prove that there are no laws of history. In both instances the antecedents of the phenomenon are irresistibly working out their results; though, in both cases, they are so complicated that no human skill can accurately anticipate their course. But to a different presentment of Mr. Froude's question we might return a different answer. There is a sense in which movements like Mohammedanism and Buddhism, or Christianity, could not have been predicted, and there is a sense in which they could have been. What could not have been predicted was the peculiar character impressed upon these movements by the gigantic personalities of such men as Mohammed and Omar, Sakyamuni, Jesus, and Paul. What could have been predicted was the general character and direction of the movements. For example, as I shall show in a future lecture, Christianity as a universal religion was not possible until Rome had united in a single commonwealth the progressive nations of the world. And, when Rome had accomplished this task, it might well have been predicted that before long a religion would arise which should substitute monotheism for polytheism, proclaiming the universal fatherhood of God and the universal brotherhood of men. I admit that such a prediction could have been made only by a person familiar with scientific modes of thought not then in existence; but, could such a person have been present to contemplate the phenomena, he might have foreseen such a revolution in its main features, as being an inevitable result of the interaction of Jewish

Hellenic, and Roman ideas. I am inclined to think he might have foreseen that it would arise in Palestine, that its spread would be confined to the area covered by Roman civilization, and that its work would be most thorough in the most thoroughly Romanized regions.

"I would not, however, insist upon this point; nor is it necessary to do so. In none of the concrete sciences is there any thing like thorough and systematic prevision, save in astronomy; and even in astronomy our foresight becomes precarious as soon as we pass beyond the solar system and begin to inquire into the mutual gravitation of the innumerable stellar bodies. We know that our sun is rushing with immense velocity toward the constellation Hercules; but we cannot yet trace his orbit as Kepler traced the orbit of Mars. When we come to biology and psychology, the power of accurate prevision is very small; yet no one denies that the phenomena of life and intelligence conform to fixed and ascertainable laws. In sociology we must expect to find still less ability to predict. The truth is, as Comte acutely pointed out, that while in the simpler sciences our object is gained if we can foretell the course of phenomena so as to be able to regulate our actions by it, in the more complex sciences our object is gained when we have generalized the conditions under which phenomena occur so as to be able to make our volitions count for something in modifying them. We cannot modify astronomic phenomena, but we can predict them. We cannot predict, save to a limited extent, biologic phenomena; but, knowing more and more thoroughly the conditions under which they occur, we can more and more skilfully modify them so as to insure health or overcome disease. And obviously even this limited ability to modify the phenomena implies a certain amount of prevision, enough to justify us in asserting that the phenomena conform to law. The case is similar in sociology. Though we may not be able definitely to predict a given political revolution, we may, nevertheless, understand the general movement of affairs, and the effects which certain kinds of legislation are likely to produce, so as to hasten a desired result or avert social mischief. Upon this possibility are based all our methods of government and of education. And, as in biology, this ability to modify the phenomena proves that the phenomena occur in some fixed order of sequence. For, where there is no definite order of sequence among phenomena, we can neither predict nor modify them; and, where there is a definite order of sequence, there is, or may be, a science.

"Now, in denying that there is or can be a science of history, Mr. Froude, if he means any thing, means that social affairs have no fixed order of sequence, but are the sport of chance. Either Law or Chance—these are the only alternatives, unless we have recourse, like the Mussulman, to Destiny, an illegitimate third idea, made up of the other two, misconceived and mutilated in order to fit together. But for the modern thinker there is no middle course. It is either symmetry or confusion, law or chance, and between the two antagonist conceptions there can be no compromise. If the law of causation is universal, we must accept the theory of law. If it has ever, in any one instance, been violated, we may be excused for taking up with the theory of chance. Now, we know that all the vast bodies in this sidereal universe move on for untold ages in their orbits in strict conformity to law. In conformity to law the solar system in all its complexity has grown out of a homogeneous nebula; and the crust of the cooling earth has condensed into a rigid surface fit for the maintenance of organic life. Out of plastic materials furnished by this surface, and the air and moisture by which it is enveloped, organic life has arisen and been multiplied in countless differing forms, all in accordance with law. Of this aggregate of organic existence, man, the most complex and perfect type, lives and moves and has his being in strict conformity to law. His periods of activity and repose are limited by cosmic rotations. His achievements, physical and mental, are determined by the rate of his nutrition, and by the molecular structure and relative weight of the nervous matter contained in him. His very thoughts must chase each other along definite paths and contiguous channels marked out by the laws of association. Throughout these various phenomena, already generalized for us by astronomers, geologists, biologists, and psychologists, we know that neither at any time nor in any place is law interfered with—that yesterday, to-day, and forever, the effect follows the cause with inevitable and inexorable certainty. And yet we are asked to believe that in one particular corner of the universe, upon the surface of our little planet, in a portion of the organism of one particular creature, there is one special phenomenon, called volition, in which the law of causation ceases to operate, and every thing goes helter-skelter!"

LITERARY NOTICES.

FARADAY AS A DISCOVERER: By JOHN TYNDALL. New York: D. Appleton & Co., 1868.

MICHAEL FARADAY: By Dr. J. H. GLADSTONE, F. R. S. London: 1872.

NOTICE SUR MICHEL FARADAY, sa Vie et ses Travaux: A. DE LA RIVE. Geneva: 1867.

THE name of Faraday has been a familiar one to all of us for many years. As students, it was in our class-books, occurring on page after page, with others nearly as familiar; and it is almost ludicrous to remember the notion we had, as boys, of the men whose works were before us. Their names were the only realities to us; their real existence was a vague concession to authority; the possibility of knowing any thing of their true life and character was too remote to be considered.

Their work was before us, and the hand that did it unknown. Liebig was a myth, Regnault a shadow, the double-headed Dulong et Petit a visionary Cerberus who barked at error. Afterward we began to know more of them as lecturers, or by their portraits, and, to some of us, Herschel, Faraday, Tyndall, are as real as our friends. And how delightful it was, this making friends of our shadowy acquaintances; how grateful we were to Arago for his long series of *éloges* of great men! The curious steel portrait of Laplace prefixed to the French editions of his "Système du Monde" told us much of him, but how much more we knew from Arago's anecdote of this towering genius, who could and did pronounce an opinion on the probable duration of the solar system; how one day he, sitting in his study, was timidly approached by Madame de Laplace, with the request that he might "intrust" to her "the key of the sugar." He, a "peer of France; Grand-officer of the Legion of Honor; one of the forty of the French Academy; of the Academy of Sciences; member of the Bureau of Longitude of France; of the Royal Societies of London and Göttingen; of the Academies of Science of Russia, Denmark, Sweden, Prussia, the Low Countries, Italy," etc., *he* with the "key of the sugar!"

So, we first began to know Faraday as a man, through a steel engraving of him published by the Society for the Diffusion of Useful Knowledge; and the promise in his youthful, tender face we may read fulfilled in the books before us. Prof. Tyndall's book contains two engravings of Faraday, with the fire of his young face subdued to a peaceful light; and, if this volume should pass to a second edition, it would add to its value as an exponent of Faraday's *inner* life, to include in it a copy of one of his early portraits. Its title is "Faraday as a Discoverer," but in spite of its title we cannot but know of the sweetness and light of his character; as if, indeed, it were impossible to conceive of his place as a philosopher, without knowing somewhat of the man.

His "Life and Letters," by Dr. Bence Jones, gives best a conception of his development as a man and as a scientist, for it is shown by his own hand. And yet these tributes of his three friends must be read to understand him; and, in reading these, you cannot fail to be struck with one thing, which is in itself a key to his character.

Dr. Gladstone proposes to treat of his "life and noble character" so as to be appreciated by those who "cannot follow his scientific researches," and yet one gathers from this life his scientific methods and a knowledge of his principal results: De la Rive and Tyndall mean to speak chiefly of his work, and yet they *must* turn aside to tell of his loveliness of disposition. The truth is that, in his life, science was not a thing apart; he lived in it; his house and his laboratory joined, and his thoughts knew no difference as to place.

In reading these books you are not struck with the wonderful facts of his life; that he should be born a smith's son, and die a member of seventy-three scientific bodies; it requires an effort to remember this, for from the first you feel, with De la Rive, that he had that condition which exists but rarely, "*c'est le génie.*" E. S. H.

QUARTERLY GERMAN MAGAZINE. (Berlin, 1872, CARL HABEL.) This appears to be intended for English readers, but a slight acquaintance with German will be found of great use for whoever wishes to find out what the writers are driving at. Not hav-

ing seen the original German of the two papers which make up the second number of this serial, we are not prepared to say whether they contain any thing novel or interesting about the matters they treat of. On the whole, it were better to convey scientific instruction to English-speaking people in the English language.

PROCEEDINGS AT THE INAUGURATION OF THE BUILDING FOR THE DEPARTMENTS OF ARTS AND OF SCIENCE IN THE UNIVERSITY OF PENNSYLVANIA; ALSO SPECIAL ANNOUNCEMENT OF THE ORGANIZATION AND COURSE OF STUDY OF THE NEW DEPARTMENT OF SCIENCE, SAME UNIVERSITY.

THE Appendix to the "Proceedings" contains two very brief notices of the life and labors of the late John F. Frazer, LL. D., Professor of Natural Philosophy and Chemistry, and editor of the *Journal of the Franklin Institute*. The new Department of Science, established in the university, allows the student to make his choice of a professional training between the following four courses: Chemistry and Mineralogy; Geology and Mining; Civil Engineering; and Mechanical Engineering.

A POPULAR TREATISE ON GEMS, by Dr. L. FEUCHTWANGER. New York, 1872. Published by the author, No. 55 Cedar St.

THIS useful work, now in its fourth edition, is intended as a guide for the teacher of natural science, the lapidary, jeweller, and amateur. It is, in the best sense of the term, a *popular* treatise, explaining the chemical constitution and properties, and the geological character, of all the substances known as gems, in such a manner as to be understood by the untechnical student. The first part, which treats of mineralogy in general, is based on Nichols's "Elements," and treats of the forms, physical and chemical properties, and classification, of minerals. The second part treats of gems in general, their composition and geographical distribution, and describes the various ways of grinding, polishing, and setting them, as also the methods of producing gems artificially. The third and last part is devoted to the consideration of the various species of gems, in the order of their commercial value. The Appendix contains a full chronological list of works on gems, which will be of great service to the student who desires to form an acquaintance with the literature of this branch of mineralogy.

BOOKS RECEIVED.

Annual Report of the Board of Health, to the General Assembly of Louisiana. New Orleans, 1872.

Proceedings of the Agassiz Institute, Sacramento, Cal. With the Constitution and By-Laws. Sacramento, 1872.

Fourth Annual Report of the Secretary of State, of the State of Michigan, relating to the Registry and Return of Births, Marriages, and Deaths. For the Year 1860. Lansing, Mich., 1872.

Popular Address on Organic Reform, delivered before the Illinois State Medical Society, at Rock Island, for the Session of 1872. By A. L. McArthur, M. D. Chicago, 1872.

New Theory of the Origin of Species. By B. G. Ferris. New Haven, 1872.

On a Method of detecting the Phases of Vibration in the Air surrounding a Sounding Body. By Alfred M. Mayer, Ph. D.

MISCELLANY.

Experiments on Sound.—Prof. Mayer, of the Hoboken Technological Institute, N. J., has made some rare and remarkable researches on sound, of which he lately gave an account before the Lyceum of Natural History, New York. The following is a summary of the views he presented: That sound reaches the ear by a series of waves or undulations, is a generally-accepted fact. But, although so accepted, it may well be doubted whether many persons, even among those of considerable general culture, are possessed of a clear view of the nature of these waves. To obtain this, it is necessary to bear in mind that the waves of sound which take place within a gaseous medium are in no wise similar to those waves which undulate on the surface of water or other liquids. The latter form around their point of origin in concentric

circles; the former are generated around that point in concentric *spheres;* all deviations from these forms being in both cases due to mere special disturbing influences. This conception having been fixed in the mind, it is readily seen that sound-waves consist of alternate swellings (involving a rarefaction) and contractions (involving a condensation) of the air, propagated from the point of origin, and that the thickness (length) of each wave is measured by the distance between the curved surfaces corresponding to the periods of maximum swelling (rarefaction) and contraction (condensation). Within the wave-limits, the progress of sound-motion is by no means uniform; and, could we accurately trace the steps in variation, we could readily delineate the march of sound within the wave.

This result may be obtained approximately by attaching a small piece of copper-foil to one of the prongs of a tuning-fork, and quickly drawing this (while vibrating) across a plate of smoked glass. A very beautiful representation of this march of sound may also be obtained by operating with an organ-pipe, having a hole at the middle (nodal-point), which is covered by a thin elastic membrane, offering no impediment to the transmission of the undulations. Directly over this membrane a little box or capsule is placed, through which a current of illuminating gas is conducted to a jet burning in front of a revolving mirror. The sound-waves being communicated to the gas, give rise to a series of flame-pulsations. When the mirror revolves, the quiet flame is reflected as a continuous, the pulsating flame as a serrated, band of light.

If, at this point of the experiment, the aid of one of Helmholz's resonance-spheres be called in—the resonance-waves being conducted by a pipe through a box and membrane (like those already described), to a second gas-jet placed exactly under the first—the image in the mirror will be duplicated. The resonance-spheres (resonators) here mentioned are thin, hollow, brass globes, with two openings opposite to each other; one being furnished with a neck for attaching a pipe, the other serving as a mouth for receiving sound-impulses. They act by sympathy, as it were, taking up and resounding with a special note, and that only, the special character of the note depending upon the relative capacity of the sphere, and the size of the mouth.

As the waves of sound, propagated through a uniform medium, travel with uniform velocity, it follows that, when the pulsations transmitted to the first jet from the organ-pipe, and the pulsations transmitted to the second jet from the resonance-sphere, pass through equal lengths of air, they will be reflected from the revolving-mirror as coincident serrations. When, however, the pulsations from the organ-pipe are transmitted through a depth of air equal to one wave-thickness or length, and the pulsations from the resonance-sphere are transmitted through a depth, either less or more (and not an exact multiple) than the wave-thickness or length, the two serrated bands of light, reflected from the revolving-mirror, will not be coincident. If, starting with equal distances of the organ-pipe and resonance-sphere from the jets, that of the latter be gradually increased, the serrations of the two images will be at first coincident, then non-coincident; then, when a distance of two wave-thicknesses is reached, again coincident, then again non-coincident; each coincident corresponding to a distance equal to a simple multiple of the wave-length of the note. And if, on the other hand, the resonance-sphere be moved in such a manner that the coincidence of the serrations is not disturbed, it is evident that the motion must be in lines traced upon the curved surface of a body of air—exactly similar in size and form to one, two, three, etc., pulsations sent forth by the organ-pipe. Prof. Mayer was the first to trace the surface of sound-waves by this beautiful and ingenious method. It is highly probable that, by this arrangement, some hitherto unapproachable acoustic problems may meet with a solution.

The velocity of sound is not influenced by variations in the density of a uniform gaseous medium, provided the temperature of this medium remain stationary. But, when the temperature changes, the velocity is at once affected. Hence, a gradual rise in the temperature of the air, passing from the resonance-sphere to the gas-jet, will be productive of a successive alternation of coincidences and non-coincidences of serrated

images, analogous to the alternations produced by increase of distance. This remarkable fact Prof. Mayer proposes to employ in measuring temperatures, and particularly the high temperatures of furnaces. This is to be accomplished by interposing a coil of porcelain or other fireproof pipe between the resonance-sphere and the jet, and introducing it slowly into the furnace. By this method, Prof. Mayer expects to be able to measure temperatures with an accuracy equal to about twenty-five degrees of the Centigrade thermometer, or even less.

A New Species of Rhinoceros.—A writer in *Nature* is disposed to see, in the hairy-eared, two-horned rhinoceros at present in the menagerie of the London Zoological Society, a new species, which he proposes to call *R. casiotis*, the hairy-eared rhinoceros. When this animal arrived in England, it was taken to be the Sumatran rhinoceros, though naturalists were surprised that a Sumatran rhinoceros should be taken so far north as was this specimen —Chittagong, the northern extremity of the Bay of Bengal. There is a fringe of long hairs on the posterior rim of the otherwise naked ears, and the tail is long, and tufted at the extremity. The head is very broad, and the skin comparatively smooth.

Nothing new under the Sun.—Humboldt, in his "Cosmos," states that the Chinese had magnetic carriages with which to guide themselves across the great plains of Tartary, one thousand years before our era, on the principle of the compass. The prototype of the steam-engine has been traced to the eolipyle of Hero of Alexandria. The Romans used movable types to mark their pottery, and indorse their books. Mr. Layard found in Nineveh a magnifying lens of rock-crystal, which Sir D. Brewster considers a true optical lens, and the origin of the microscope. The principle of the stereoscope, invented by Prof. Wheatstone, was known to Euclid, described by Galen fifteen hundred years ago, and more fully in 1599 A. D., in the works of Baptista Porta. The Thames Tunnel, thought such a novelty, was anticipated by that under the Euphrates at Babylon; and the ancient Egyptians had a Suez Canal. Such examples might be indefinitely multiplied, but we turn to photography. M. Jobard, in his "Nouvelles Inventions aux Expositions Universelles," 1857, says a translation from German was discovered in Russia, three hundred years old, which contains a clear explanation of photography. The old alchemists understood the properties of chloride of silver in relation to light, and its photographic action is explained by Fabricius in "De Rebus Metallicis," 1566. The daguerreotype process was anticipated by De la Roche in his "Giphantie," 1760, though it was only the statement of a dreamer.

The Sun as a Borer of Mountains.—1. The universe is filled with rays of heat and light, which vibrate among the heavenly bodies perpetually without loss or gain, and which, on alighting upon a heavenly body, pass first into common sensible heat, to be reflected afterward as cold, invisible rays.

2. Of the inexhaustible supply of these rays, our sun receives at every instant of time as much as he radiates back again.

3. A portion of his rays fall upon our earth, where they are converted into sensible heat.

4. By means of this sensible heat, water is converted into aqueous vapor; the sensible heat being at the same time changed into so-called *latent* heat, or chemical motion.

5. Aqueous vapor having less specific gravity than air, it ascends and represents a lifted weight. In this process, heat is converted into motion—the ascent of the weight.

6. The expansion of the air (during which heat is converted into mass-motion) causes the aqueous vapor to be spread over the surface of the earth.

7. By the condensation of the aqueous vapor, chemical motion escapes as common heat, and the resulting water is deposited on the mountain-heights in the form of snow; thus, again, representing a lifted weight.

8. The warm winds from the Mediterranean melt the snow and glacier-ice; sensible heat is thus converted again into insensible chemical motion.

9. The downward current of the Alpine streams generates motion in virtue of their mass, and of the space passed over during their descent.

10. This mass-motion, when temporarily checked by any resisting object, is converted back into heat.

11. Man arrests a portion of this motion by means of a large water-wheel, and, by the aid of a crank and a connecting-rod, transmits the motion to the piston-rod of an air-compressor.

12. In compressing air, we accumulate motion as a force or tension; and the compressed air yields this force again without loss (exception made of the loss occasioned by the friction of the piston, which reappears as heat).

13. Compressed air — a storehouse of motion—is made to pass into a contrivance similar to the steam-chest of a steam-engine, where a sliding-valve forces the air to enter alternately above and below the piston to which it thus imparts common mass-motion. The process is the same as the one operating in the steam-engine, with the difference that the motor agent is compressed air in place of steam, and that the motion is ultimately obtained, not from the combustion of fuel, but from the descent of water.

14. The mass-motion of the water, now transferred to a drilling-machine, is modified by means of mechanical contrivances in a manner such that powerful blows are dealt in rapid succession upon the cutting-tool which drills the hole; mass-motion is thus converted back into heat.

15. The drill-hole is filled with a mixture of substances containing chemical motion, which, at any time, may be given out as heat and mechanical motion. By the ignition of the mixture, new combinations of substances occur, which, owing to the new distribution of chemical motion, take up a much greater space, and thereby split the rocks.

16. Mont Cenis Tunnel (as will be the future one of St. Gothard) was bored by the sun's heat.—*Mohr, translated by Hotze.*

Cinchona in Bengal.—In 1862 Dr. T. Anderson began the cultivation of cinchona (the tree that yields the Peruvian bark) in Sikkin, Bengal. The venture has proved profitable; and at the present time he has under cultivation cinchona trees of three species, to the number of 1,707,115, yielding about 300 pounds of bark per acre. Besides these, he has 480,000 young plants in nursery.

Bulb-Culture in Holland.—Although one-fifth of the entire land in the Netherlands is worthless for cultivation, and another fifth is meadow-land, yet 47,500 acres of the remainder are devoted to tobacco, 35,000 to hemp, and 500 acres to raising tulips, hyacinths, and other flowering bulbs. Holland has ever excelled in this sort of horticulture.

Antiseptic Properties of Borax.—A paper by M. Jacquez on the preservative action of borax and the sub-borate of ammonia, on animal matter, read before the French Academy of Sciences, gives an account of some important experiments made by the author during a period of five years, with a view to ascertain the antiseptic properties of the substances named. In June, 1853, he dissolved 25 grammes (about 387 grains) of gelatine in 100 grammes (a little over 3 ozs. of water) with 4.50 grammes—nearly 70 grains—of borax. The mixture remained in an open flask all through the summer, without any sign of mould or putrefaction. In August of the same year, pieces of meat dropped into a solution of borax and water (5 parts of the former to 100 of the latter) were there preserved unchanged for a month —being then taken out of the solution and exposed to the air, they dried slowly, and did not undergo decomposition. The next series of experiments was with a mixture of borax, sub-borate of ammonia, and tepid water, in the proportion of 5 or 6 parts of borax, and 10 or 12 of sub-borate of ammonia, to 100 of rain or pure river water. By injecting this mixture into the bodies of rabbits killed two days previously, the water kept them without sign of decomposition for several months. M. Jacquez is of opinion that this process is of high importance for the dissecting-room, as it does not alter either the coloring or the firmness of the tissues, and at the same time imports no poisonous element into the subject. Futhermore, the edge of cutting-instruments

is not at all affected by the presence of the antiseptic. Probably, if 6 per cent. or even 8 per cent. of borax were used with the liquid at about 40° C. at the moment of injection, the *cadaver* itself having been previously kept for some hours in some warm medium, the borate of ammonia might be omitted. Then an adult *cadaver* might be prepared at the trifling expense of two francs. For purposes of embalming, the writer recommends a concentrated solution of both salts, injected two or three times into the blood-vessels at intervals of a few days. Pulverized borax would also be of service in preserving the skins of stuffed animals and birds; and the solution might be used instead of alcohol in cases where the latter is now employed to preserve specimens.

Disintegration of Tin.—Two cases of the disintegration of tin are given in the *American Artisan*, the phenomenon being in the one case traceable to the action of intense cold and long-continued vibration, while in the other the cause of the disintegration is unknown. A certain quantity of tin in ingots was shipped from Rotterdam to Moscow by rail during extremely cold weather. On reaching its destination it was found to have been reduced to a powder, with coarse crystalline grains. When fused, instead of forming a solid mass, it gave only oxide of tin, a gray powder. The second case was that of two pigs of "Banca tin," purchased by the United States Ordnance Bureau. They had lain in store for several years; and, when at length they were taken from their resting-place, one was found almost entirely reduced to a gray powder, while the process of disintegration in the other was as yet confined to the edges. Dr. I. Walz, who communicates to the *Artisan* this piece of information, tried in vain to learn the previous history of these two pigs of tin. It is his belief that the instances here recorded are the only ones known of tin assuming a granular condition.

A Squirrel-Pest.—In some parts of Arkansas the squirrels were so numerous the past season that they destroyed entire fields of corn. As many as 125 have been killed by one person in a day.

Welding Copper.—According to the *Journal of the Franklin Institute*, Mr. Rust has succeeded in perfecting a method by which he accomplishes a perfect welding of copper. He mixes together 358 parts of phosphate of soda and 124 parts of boracic acid. This powder is applied when the metal is at a low red heat; it is then brought to a cherry-red, and at once hammered with a wooden hammer.

Effect of Atmospheric Pressure.—Mr. Paul Best, in a very interesting memoir, shows that the destruction of life by diminished barometric pressure is chiefly to be attributed to deficiency of oxygen. An animal that will die with the pressure reduced to 18 centimetres (7 inches) of mercury, will endure a reduction to 6 centimetres (2.4 inches) if an additional supply of oxygen be furnished. And the converse is also true, that the danger of too great pressure is from the increased amount of oxygen in a given volume of air inhaled.

Relations of Local Diseases to the Nature of the Soil.—Dr. Moffat read before the British Association a paper on the above subject, in which he shows that the nature of the soil exercises considerable influence on the character of endemic disease. His district lies on the carboniferous and red, or Cheshire, sandstone formation. Anæmia is the prevailing condition of the inhabitants of the carboniferous land, who are both miners and farmers, while it is almost unknown on the red sandstone. Consumption is also more prevalent in the first-named district. Since anæmia is a want of iron in the blood, Dr. Moffat examined the constitution of wheat grown on the Cheshire sandstone, and found it produced much more ash, and hence a larger proportion of mineral constituents, including oxide of iron, than that grown on the carboniferous soil. He estimates that a pound of wheat from the first furnishes five grains more of oxide of iron to the consumer than a pound of wheat from the second soil, which accounts for the comparative poverty of the blood of the miners in iron and phosphoric acid. An examination of the blood of the animals kept in the two districts confirmed the above observations.

Sensitive Streams. — Prof. Edwin J. Houston, while spending a summer's vacation in Pike County, Pa., had the good fortune to discover the sensitiveness of water to sound-waves. Among the many beautiful water-falls of that section he found one scantily supplied with water, which dripped in small streams from the ends of the moss covering the rocks of the precipice; the air being still and the stream free from ventral segments. And it was found that, on sounding a shrill *falsetto* note, the streams would instantly respond, and change the grouping of the drops and the position of the ventral segments. A heavy rain, however, flooded the stream, and prevented further investigation.

Vegetable Caprice.—It would almost seem that too much can be asserted as to the uniformity of habitat, or natural location, of a given species of plant. The Bunch-flower (*Melanthium Virginicum*) has been set down as invariably occupying moist meadows and damp borders. A correspondent of the Torrey Botanical Club reports seeing, "when crossing the Alleghanies by carriage-road to the Peaks of Otter, and frequent, high and dry, on the rocks, tall and stout *Melanthium Virginicum*," and adds: "I was unprepared for that, as with us it grows along the margins of marshes, as at Bergen, N. J."

The Tails of Comets.—Prof. Zöllner, in his book "On the Nature of Comets," accounts for some of the phenomena by showing that water, mercury, and many other substances, even in the solid state, always give off vapor; hence, a mass of matter in space will ultimately surround itself with its own vapor, and present the appearance of a comet. It is quite probable that some of the masses moving in space may be fluid, in which case, on approaching the sun, the development of vapor would be very rapid, as is well exemplified by some of the smaller comets. And, as regards the swift growth of the tail, Prof. Zöllner demonstrates that if the free electricity of the sun be not greater in amount than that observed at the surface of the earth, it would be sufficient to communicate an impulse which, as exemplified by the comet of 1680, would produce a train or tail 60,000,000 miles long in two days. Having proved this mathematically, he does not think it necessary to seek further for a theory of repulsive force by which to account for the tails of comets.—*Chambers's Journal.*

Phosphoric Acid.—The occurrence of phosphorus in combination with the ores of iron has long been an annoyance to iron-manufacturers, and many rich ores are worthless from the presence of phosphorus, which makes the iron brittle and useless. Julius Jacobi proposes a method of freeing iron-ores from phosphorus, and at the same time saving the phosphoric products for agricultural purposes. His process consists in roasting the ore and crushing it, and, after placing it in a proper receiver, submitting it to the action of water charged with sulphurous acid under pressure. The ore is then washed with water to remove all the soluble products, and the phosphoric acid precipitated from the water with fresh-burnt lime is obtained as a neutral phosphate of lime. If effectual, and not too expensive, the proposed method is very important, as rendering many ores available which are now regarded as worthless, and at the same time supplying a demand in agriculture which has heretofore been but imperfectly met.

The Osage Orange.—The *Maclura aurantica*, a familiar shrub from its general use as a hedge-plant, it is now proposed to utilize for other purposes. A decoction of the wood is said to yield a beautiful and very permanent yellow dye. This decoction, carefully evaporated, forms a bright-yellow extract, called *aurantine*, which may be used in imparting its color to fabrics. In addition to this coloring-matter, the wood of the Osage orange is rich in tannin. Experiments made in Texas represent that hides are tanned quicker with the wood of this tree than with oak-bark. The seeds yield a bland, limpid oil, resembling olive-oil, and which may, in general use, be substituted for it.

Test for Silk Goods.—In the present methods of silk manufacture the amount

of adulteration to which the fabric is subjected is enormous. Although linen is often used, the favorite adulterator is jute, which is cheaper, is heavy, and so easily takes the dye, and in other ways is made to simulate the silk, that it is the more difficult of detection by an unpracticed eye. If a sample of the "goods suspected to contain other kinds of fibre be treated with hydrochloric acid of 1.13 specific gravity, the silk will be dissolved, while other kinds of fibres, such as jute and linen, will remain undissolved."

Opium-poppy in France.—The cultivation of the opium-poppy in France is steadily increasing. It now occupies 50,000 acres, of the value of 4,500,000 francs, yielding opium to the value of 2,000,000 francs a year. Different samples of opium, raised in various parts of Europe, are said to have yielded from 8 to 13 per cent. of morphine.

NOTES.

THE Volcano of Santorin, when last visited, in October, 1871, had ceased giving the small eruptions which had been common almost without intermission since the great eruption of 1866, and the summit of the crater, covered with great blocks of lava, presented the same appearance as in 1707. A little steam was still escaping, but this seemed due almost entirely to the vapor of water condensing on the cinders covering the cone. In the north the fumerolles were still active, and all around the stones were covered with sulphur. At the southeast point the volcanic activity had not completely ceased, but had greatly diminished. All this would show that the eruption had entered on its last stage, and after a period of great central activity in 1866–'67, accompanied by a diminution of activity in 1869–'70, it is now again assuming a condition of rest and quietude.—*Nature.*

Colonel Weitzel, of the Brussels Congress, tells of a village on piles, still inhabited, on the island of Noessa Kimbaugan, off the south coast of Java. Its inhabitants live by fishing. On being asked by Colonel Weitzel why the village was built out into the water, one of the inhabitants said that it was in order to be secure against the attacks of tigers.

ENGLISH SPARROWS IN AUSTRALIA.—Complaints are received by the Royal Horticultural Society that fruit-crops in Australia have been seriously injured by the English sparrows imported into that country.

THE dolmens, or cromlechs, of Algeria, was the subject of an address by General Faidherbe before the Brussels International Congress. He considers the cromlech to be a monument indicating a place of interment, and thinks it has no other purpose. According to him, the area in which cromlechs are to be found extends from Pomerania to Africa. That none exist in Belgium he accounts for by the great density of the population, the cromlechs having been there cleared away.

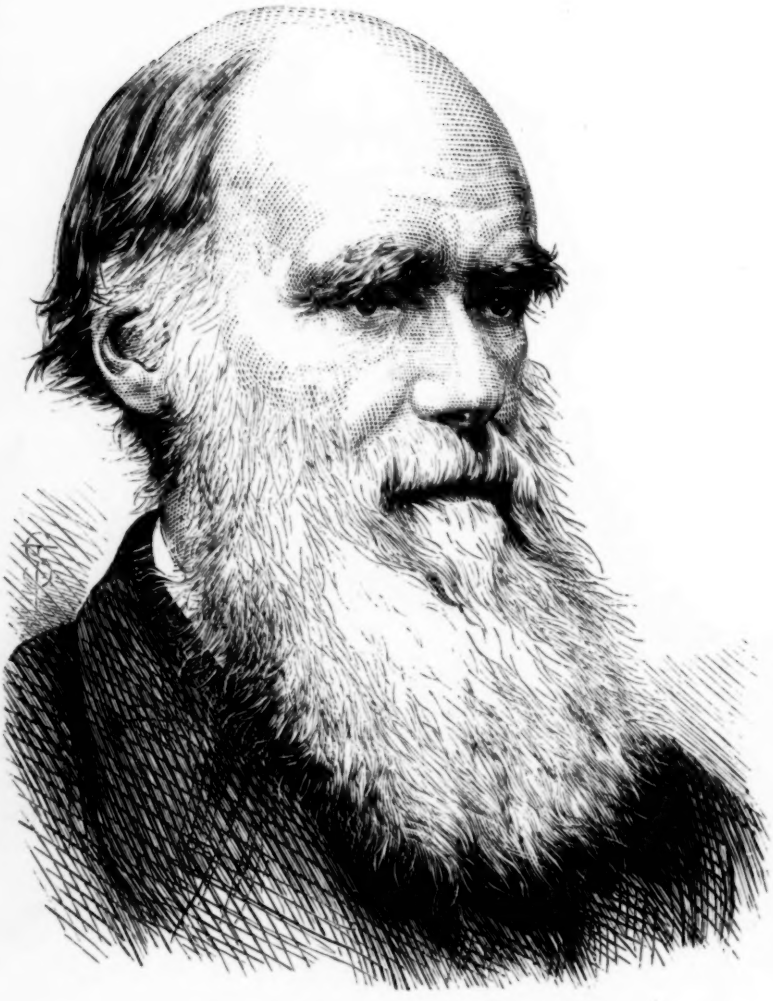
WE take from the *Journal of the Franklin Institute* the following facts in microscopic photography, contributed by L. Erckmann: Thin sections of plant preparations laid overnight in aniline red solution came out thoroughly colored. When washed in water, the nitrogenous parts retain the red, the non-nitrogenous giving it up. But, if the solution is too concentrated, the image, seen through the microscope, will be red throughout. As the red rays have but little action upon silver iodide, a positive print will show very dark in the nitrogenous, and lighter in the other portions.

IN Great Britain and Ireland there are about 30,000 coal-mines, yielding 120,000,000 tons per annum. The depths from which this coal is raised vary widely—the deepest workings being the Dunkinfield and the Rosebridge collieries, near Wigan. The depth of the latter is 2,418 feet, and the average temperature 95° Fahr.

WE have in the *Gardener's Chronicle* a remarkable instance of the luminosity of fungi. The spawn of some unknown species of fungus, growing on a trunk of spruce or larch, was found to give a perfect blaze of white light along the track where the trunk had been dragged. The light was enough to read the face of a watch, and it continued for three days.

ATTENTION has lately been directed to a new method for printing on cloth, the invention of Mr. E. Vial. The fabric to be printed is first impregnated with a solution of nitrate of silver, or other metallic salt, which, when brought in contact with zinc or copper, will be reduced to the metallic state. The patterns are designed on zinc or copper, and, wherever contact is made between the metal plate and the cloth, a metallic precipitate is firmly fixed upon the tissue. If nitrate of silver is used, the color of the precipitate, and therefore of the cloth, may be varied by varying the strength of the solution, from a brilliant gray to a deep black. The color withstands acids, alkalies, or soaps.

THE sewage of Tunstall, in Staffordshire, England, is to be converted into cement by precipitation, by the process of Major-General Scott. This system is already in operation in Birmingham, West Ham, and Ealing.



CHARLES DARWIN, M. A., F. R. S., Etc.